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Project Closeout and Transition Plan for Soil and Water Remediation-Lawrence Livermore National Laboratory – Main Site (VL-LLNL-0030)

and

Solid Waste Stabilization and Disposition – Lawrence Livermore National Laboratory (VL-LLNL-0013)

U.S. Department of Energy
National Nuclear Security Administration
Livermore Site Office

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1. Introduction

The following information documents the Livermore Site soil and ground water remediation project (PBS VL-LLNL-0030) and the solid waste stabilization and disposition project (PBS VL-LLNL-0013) closeout and transition plan for closure of the Environmental Management (EM) projects at the Lawrence Livermore National Laboratory (LLNL) National Nuclear Security Administration (NNSA) site. After closure of the EM project, NNSA will assume responsibility for initiating Long-Term Stewardship. The LLNL Livermore Site is a research and development facility owned by the Department of Energy (DOE) and operated by the University of California. It is located approximately three miles east of downtown Livermore, California (Fig. 1).

This document follows EM's *Project Closeout and Transition Plan Guidance for Environmental Projects at National Nuclear Security Administration Sites*. The purpose of the Project Closeout and Transition Plan is to provide a framework for the closeout of the two Environmental Management (EM) projects at LLNL. The PCTP is a tool to help facilitate a smooth transition from active EM remediation projects to NNSA-led Long-Term Stewardship (LTS), by providing a systematic process to utilize in analyzing the baseline, and understanding and managing actions from completion of the EM mission through transition into LTS. As stated in this guidance, this Project Closeout and Transition Plan is the primary document in the Critical Decision-4 (CD-4) package. The guidance also states that information included in this plan is expected to be more thoroughly detailed in other documents and that other documents will be referenced accordingly.

The solid waste stabilization and disposition project (PBS VL-LLNL-0013) was completed in November 2005. This project has no activities transferring from EM to NNSA. This document primarily addresses the completion of the soil and ground water remediation project (PBS VL-LLNL-0030) and the transition of long-term stewardship activities to NNSA, although it does certify the completion of the solid waste stabilization and disposition project (PBS VL-LLNL-0013).

By the end of FY 2006, all the milestones identified in Table 5 of the Remedial Action Implementation Plan (Dresen et al., 1993a) for the soil and ground water project (PBS VL-LLNL-0030) will have been completed and the project will be ready for transition. Additional construction and upgrades will occur beyond FY 2006; however, these are not identified milestones by the regulatory agencies and the community.

No barriers to knowledge transfer are anticipated at the Critical Decision-4 transition as the personnel working on the project will remain in place after the transition to Critical Decision-4. Documentation will also reside with the personnel currently working on the project.

2. Authorities and Accountabilities

The Terms and Conditions of the soil and ground water project's transition from EM to NNSA are outlined in the EM/NNSA Terms and Conditions document. Specific roles and

responsibilities for each organization are listed in that document, as well as budgetary obligations prior to transfer.

3. Site Conditions

3.1 Environmental Restoration Site Conditions

3.1.1 Remedies and Hazards

The following briefly describes the site historical uses, characterization, remedial actions, and remedies and remaining hazards.

3.1.1.1. Physical Features

The Livermore Site comprises approximately 800 acres. The Diablo Range hills flank the site to the south and east, and the ground surface slopes down approximately 1% to the northwest. The site is underlain by several hundred feet of interbedded alluvial and lacustrine sediments.

Ground water beneath the site is partly within the Spring and Mocho I hydrologic subbasins (California Department of Water Resources, 1974). Depth to ground water at the site varies from about 130 feet (ft) in the southeast corner to about 25 ft in the northwest corner. Municipal wells about two miles west of the site supply water to downtown Livermore. Ground water south and west of the site is used for agricultural irrigation. Two intermittent streams, Arroyo Seco and Arroyo Las Positas, are located on the site and recharge the ground water during wet periods.

The ground water contamination is controlled by six different hydrostatigraphic units (HSUs) as shown on Figure 2. HSU analysis integrates chemical, hydraulic, geophysical, and geological data into a detailed three-dimensional model of the subsurface. Through HSU analysis, DOE/LLNL have been able to depict the location of underground contaminant plumes in relation to individual source areas, and gain a better understanding of contaminant transport and distribution. HSU methodology has allowed DOE/LLNL to target individual contaminant plumes, place extraction wells at optimum locations to meet cleanup objectives faster, and conduct a comprehensive and more cost-effective cleanup.

3.1.1.2. Residual Hazards and Controls

Ground water and soil vapor treatment facilities are the engineered control for controlling and cleaning up the contaminated ground water and soil. The extent of the ground water and soil contamination is shown in Figure 3 and treatment facility locations in Figure 4 (Geographic Information Systems [GIS] references: LLNL GIS and ESRI ArcGIS CD).

Institutional controls include site access restrictions by the site remaining a secured DOE facility.

3.1.1.3. Structures and Utilities

The Livermore Site will remain an active DOE facility for the foreseeable future. Management of buildings and utilities will continued as currently managed through NNSA. The treatment facilities installed during the EM project work will continue to operate, and NNSA, under its Long-Term Stewardship program will be responsible for these structures until all contaminants in the ground water are at drinking water standards (Maximum Contaminant Levels [MCLs]), and unsaturated soil concentrations do not impact ground water above MCLs. The primary contaminants at the site are volatile organic compounds (VOCs), predominantly trichloroethylene and perchloroethylene. Tritium and fuel hydrocarbons are in localized areas of the site. A further discussion of contaminants is presented in Section 3.1.1.7.

Figures 4 and 5 show the locations of the treatment facility structures (GIS references: LLNL GIS and ESRI ArcGIS CD). The selected remedy in the ROD involved constructing seven fixed ground water treatment facilities that used ultraviolet/oxidation-based remediation and/or air stripping. After installing four fixed treatment facilities, LLNL began constructing and installing portable ground water treatment units for use at more locations than were specified in the ROD. The original design for Livermore Site ground water cleanup was permanent fixed treatment facilities with pipelines to transfer ground water from the extraction wells to the facilities. These portable treatment units do not require long pipelines, and are less costly to construct. They also increase cleanup flexibility because they are easily moved to different locations for aggressive remediation of areas with high contaminant concentrations, or to fill "gaps" near plume margins. These facilities have resulted in more aggressive ground water cleanup, increased cleanup flexibility, and reduced capital costs by 57% over conventional fixed facilities with long pipelines (ERD, 2004). The regulatory agencies have approved the use of the portable treatment units through Remedial Design Report No. 5 (Berg et al., 1995) and the Five-Year Reviews (Berg et al., 1997c; Berg et al., 2002).

There are currently four types of portable ground water treatment units in use at LLNL:

1. The Portable Treatment Unit (PTU), which uses air stripping to treat the ground water at a flow rate up to about 45 gallons per minute.
2. The Miniature Treatment Unit (MTU), which is a smaller version of the PTU that operates at about one-half the flow rate.
3. The Granular Activated Carbon (GAC) Treatment Unit (GTU), which uses aqueous-phase GAC instead of air stripping to treat the ground water.
4. The Solar-powered Treatment Unit (STU), which also uses aqueous-phase GAC to treat the ground water, but uses solar energy to operate the facility.

Of the 27 ground water treatment facilities currently in operation, 21 are portable treatment units; four are conventional fixed facilities, and two are fixed catalytic reductive dehalogenation units. Many facilities are surrounded by site screens to blend in with the nearby buildings. Attachment 1 contains information on each of the treatment facilities that will be active when the EM project transitions to Long-Term Stewardship in Fiscal Year 2007. Facilities no longer in operation are not included in Attachment 1. Additionally, one facility was removed in FY 2006 at the request of the institution for an upcoming construction project. This facility, which is not

contained in Attachment 1, will be moved to a new location in FY 2007. Once it is relocated in FY 2007, there will be 28 ground water facilities in operation.

3.1.1.4. Ground Water Well Locations

Figures 5a, 5b, 5c, and 5d show the location of the ground water wells. In addition, these figures show the discharge locations for the treated ground water. This includes Arroyo Seco in the southwest portion of the site and Arroyo Las Positas in the north portion of the site. Some treated ground water is discharged into Lake Haussmann on site, with controlled release to Arroyo Las Positas. Air quality sampling is conducted according to the Bay Area Air Quality Management District requirements at treatment facilities (Fig. 4) that have air emissions.

3.1.1.5. Offsite

Land immediately north of the Livermore Site is zoned for industrial use. To the west, the land is zoned for medium- to high-density urban use. Sandia National Laboratories, California is located south of the site. The area east of LLNL is zoned for agriculture and is currently used as pasture land (Thorpe et al., 1990). Offsite property use is shown in Figure 3.

3.1.1.6. Remediation Risks

The risks associated with the ongoing project are described and managed as outlined in the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) *Contingency Plan* (McKereghan et al., 1996) and the *Risk Management Plan for Environmental Restoration, Lawrence Livermore National Laboratory* (DOE, 2006). The uncertainties described include technical as well as logistical issues.

3.1.1.7. Contamination

Initial hazardous materials releases occurred at the Livermore Site in the mid- to late-1940s when the site was the Livermore Naval Air Station (Thorpe et al., 1990). There is also evidence that localized spills, unlined landfills, and leaking tanks and impoundments contributed volatile organic compounds (VOCs), fuel hydrocarbons, metals, and tritium to the ground water and unsaturated sediments in the post-Navy era.

Compounds detected in ground water beneath the site include:

- VOCs that were used by both the Navy and LLNL.
- Gasoline and diesel fuel released from Navy and LLNL storage tanks.
- Chromium from corrosion inhibitors in Navy and LLNL cooling tower discharge as well as natural sources.
- Tritium and other radionuclides used in research by LLNL.

3.1.1.7.1 Historic Contamination Levels

Eight chlorinated solvents, trichloroethylene (TCE) and perchloroethylene (PCE), 1,1-dichloroethylene (1,1-DCE), 1,2-dichloroethylene (1,2-DCE), 1,2-dichloroethane (1,2-DCA), 1,2-dichloroethane (1,2-DCA), carbon tetrachloride and chloroform were detected in

ground water in the late 1980s. TCE and PCE were the predominant VOCs and ranged up to concentrations of 5.1 and 1.6 parts per million (ppm), respectively (Thorpe et al., 1990). TCE is the most abundant VOC in ground water throughout the site; however, PCE dominates in the southwest corner of the site.

Distribution of 1,1-DCE is generally similar to TCE and PCE and was initially at concentrations below 100 parts per billion (ppb). The areal distribution of 1,2-DCE, and 1,1-DCA was much less than TCE, PCE and 1,1-DCE and was initially at concentrations generally below 30 ppb (Thorpe et al., 1990). The other contaminants had limited distribution at moderate concentrations.

Tritium was generally present in the Building 292 area and East Taxi Strip area. Fuel hydrocarbons were detected at the location of the Gasoline Spill Area.

3.1.1.7.2 Current Contamination Levels

Similar, but less extensive distribution patterns for VOCs exist currently. The VOC concentrations have been reduced significantly since remediation began. Figures 6 through 11 show the total VOC contaminant plumes for Hydrostratigraphic Units 1B through 5, respectively, as of the end of calendar year 2005.

Currently, about 1037 kilograms of VOC mass above the MCL remains dissolved in the ground water. The methodology for this estimate is presented in Attachment 2. This estimate will be revised in the upcoming Five-Year Review in 2007.

Tritium activities have been below the drinking water standards throughout the site since August 2004. Fuel hydrocarbons are being monitored as discussed further in Section 3.1.9.

3.1.1.7.3 Contamination Levels at Site Delisting

As stated in the Record of Decision (ROD)(DOE, 1992), the remedial objectives will be met when ground water concentrations are maintained at or below MCLs. There may be different Federal and State MCLs, and the stricter of the two apply. Soil concentrations will meet the remedial objectives when residual contamination do not impact ground water above the MCLs. Table 1 presents the Federal and State MCLs.

3.1.1.8. End-State Requirements

The current end state for the LLNL Livermore Site cleanup is to reduce contaminant concentrations in ground water to levels below MCLs, and prevent migration in the unsaturated zone of those contaminants that would result in concentrations in ground water above an MCL.

A Final End-State Vision document was prepared for the Livermore Site (DOE, 2005) that explored the current planned cleanup end state against a "risk-based" alternative. The only significant strategic difference between the current cleanup end state and the evaluated "risk-based" end state is the point of compliance for contaminated ground water. The two end states are identical in terms of exposure of offsite receptors to contaminants from the Livermore Site, and address risk to these receptors equivalently (Fig. 12). However, onsite cleanup of ground water under the current cleanup baseline end state is intended to restore and protect ground water as a potential future resource, rather than to specifically mitigate risk. The end-state vision

alternative presents a scenario based only on risk, but does not remediate onsite ground water to levels protective of ground water as a potential future resource.

The final analysis did not recommend the alternative end-state vision because it was more expensive than the current state, and because of strong opposition by the regulatory agencies and other stakeholders. However, the existing end state only differs from the alternative end-state vision by the point of compliance for contaminated ground water. The two end states are identical in terms of exposure of offsite receptors to contaminants from the Livermore Site, and address risk to these receptors equivalently (DOE, 2005).

3.1.1.9. Cleanup Level Basis

The selected remedy in the ROD (DOE, 1992) involved constructing ground water treatment facilities that used ultraviolet/oxidation-based remediation and/or air stripping. By October 2006, 27 ground water and 9 vapor extraction and treatment facilities will be part of the remediation network (Fig. 4). One additional ground water treatment facility will start operation in FY 2007. It was moved at the request of the institution in FY 2006 due to a construction project, and is scheduled to be relocated in FY 2007. These treatment facilities are used to meet the following remediation objectives for all contaminants originating at the Livermore Site:

- Prevent future human exposure to contaminated ground water and soil.
- Prevent further migration of contaminants in ground water.
- Reduce contaminant concentrations in ground water to levels below MCLs, and reduce the contaminant concentrations in treated ground water to levels below state discharge limits.
- Prevent migration in the unsaturated zone of those contaminants that would result in concentrations in ground water above an MCL.
- Meet all existing permit discharge standards for treated water and soil vapor, and to treat vapor so that there are no measurable atmospheric releases from treatment systems.

Cleanup levels are presented in Table 1.

The LLNL Livermore Site project has reached the end state on fuel hydrocarbons through negotiated agreements. In August 1995, the regulatory agencies concurred that remediation had successfully recovered the majority of the fuel hydrocarbons in the vadose zone at an old gasoline station, and that there was greatly diminished efficiency in continuing active remediation. The regulatory agencies also agreed that remediation efforts had met or exceeded Applicable or Relevant and Appropriate Requirements (ARARs) in the Livermore Site ROD, and that remediation of the vadose zone was complete (Gill, 1995). Vadose zone remediation of fuel hydrocarbons ceased in August 1995.

In addition, the LLNL Livermore Site project demonstrated that passive biodegradation will continue to degrade, contain, and reduce the residual fuel hydrocarbons in the ground water. In October 1996, the Regional Water Quality Control Board (RWQCB) confirmed completion of active remedial action for the fuel-impacted ground water and granted No Further Action status (RWQCB, 1996).

Of the 43 construction milestones (Table 2), 21 were installed for source area and hotspot remediation, and 6 for source area control. In addition, the following removal actions have been conducted to reduce sources:

- Taxi Strip — The Taxi Strip area was a former radioactive liquid and storage area near the current location of Trailer 5475 (Berg, et al., 1998; Buerer, 1983; Dreicer, 1985). In 1983, soil excavation, up to a depth of 34 ft, was conducted. About 3,000 cubic yards of soil was shipped off for disposal and was completed in May 1983.
- East Traffic Circle Landfill — A landfill containing paper, construction debris, capacitors, gardening debris, etc. was excavated in August through September 1984. About 160 capacitors were removed during this removal. Nearly 14,000 cubic yards of soil and debris removed containing VOCs and PCBs. All excavated materials were shipped and disposed by September 1985 (McConachie et al., 1986).
- NIF Construction Site — During the National Ignition Facility construction project, a cache of buried capacitors was discovered, which triggered further investigation and soil removal. Under an Emergency Removal Action (Bainer and Berg, 1998), 112 buried capacitors and 766 tons of contaminated soil and were removed and disposed in September 1997.
- East Traffic Circle residual soil clean up — Residual soil contamination from the East Traffic Circle Landfill removal was discovered in October 1998. Investigations and removal occurred during March through July 1999 under a time-critical removal action (Joma, 2000). Over 400 cubic yards of residual soil containing PCBs were removed and disposed from May through July 1999.

3.1.2. Conceptual Site Model

The conceptual end-state vision site model is presented in Figure 12. Detailed descriptions of this model are presented in the *End State Vision for Lawrence Livermore National Laboratory, Livermore Site* (DOE, 2005).

3.1.3. Completion of Remedial Actions

Table 2 shows the regulatory milestones and completion dates for EM remedial actions. Three FY 2006 milestones have been completed, and two milestones remain in progress. The two remaining milestones are on schedule to meet the scheduled date.

3.1.4. Future Remedial Actions

The regulators are regularly kept apprised of the milestone status and are expected to approve completion of the milestones by the end of FY 2006. The U.S. Environmental Protection Agency (EPA) will conduct a final inspection in FY 2007. To date, no other regulatory-required construction activities are identified after the completion of the FY 2006 milestones. The regulatory agencies have been informed of EM completion and the transition from EM to Long-Term Stewardship under NNSA at the Remedial Project Manager's (RPM's) meetings. There have been no concerns raised by the regulatory agencies. No regulatory-required EM Remedial

Actions are anticipated in FY 2007 and beyond. Any field construction conducted in Long-Term Stewardship will be for the purpose of enhancing the current wellfields to accelerate ground water cleanup and/or source area remediation to reduce NNSA's long term mortgage.

3.1.5. NRDA Results

A Natural Resource Damage Assessment is not known to have been conducted for the Livermore Site project. However, the CERCLA process includes collecting, compiling, and analyzing information to determine impact to resources. Of the natural resources, the impact is primarily to ground water. The Livermore Site is located in a semi-arid region in northern California, which is experiencing population growth and an ever-increasing demand for clean water. The local water purveyor has a long-term plan to use this basin to store water in order to meet the ever increasing regional water supply needs, and is therefore concerned about the potential for adverse impacts from Livermore Site ground water contamination. The remedial objectives for the CERCLA ground water cleanup is designed to restore the ground water and the underlying basin as a natural resource.

3.2. Waste Management Site Conditions

3.2.1. Completion of the Legacy Waste Project (LWP)

The Legacy Waste Project (LWP) was one of four LLNL Environmental Management Projects identified in the EM Project Baseline. Initially, the scope of work for the LWP was to disposition all of the remaining LLNL legacy waste by the end of FY 2006; however, EM-1 challenged LLNL to complete the LWP by the end of FY 2005 and without FY 2006 funds ($3.6M). The total volume of the waste subject to the LWP was 2,072 cubic meters of low level waste (LLW) and mixed low level waste (MLLW), and 88 cubic meters of transuranic waste (TRU).

3.2.1.1. TRU Disposition

The scope of work related to TRU included the packaging and shipping to the Waste Isolation Pilot Plant (WIPP) near Carlsbad, New Mexico, by the end of FY2004. LLNL played a supporting role to the Central Characterization Project (CCP) regarding the characterization and packaging of the TRU waste. The actual shipment and disposal of the TRU waste was the responsibility of the CCP.

LLNL successfully completed shipping the entire volume of legacy TRU to WIPP in January 2005. WIPP is the only facility in the United States that accepts DOE TRU for disposal. To achieve success, LLNL had to complete an Operational Readiness Review of the mobile characterization units and waste certification units that were deployed at the LLNL Decontamination and Waste Treatment Facility (DWTF). LLNL also had to complete audits conducted by the EPA, the State of New Mexico and the Carlsbad Field Office (CBFO). LLNL also provided the facilities, and ES&H management systems to ensure a safe operation.

3.2.1.2 MLLW/LLW Disposition

The scope of work related to MLLW/LLW included identifying appropriate treatment and disposal facilities, identifying data gaps in the existing data, characterizing the waste to eliminate the data gaps, process the waste for shipping to an approved disposal site and (except when treated on-site) ship the waste off-site for treatment and/or disposal. For the MLLW/LLW part of the Legacy Waste Project, there were 33 separate waste streams.

Nearly half (47%) of all MLLW/LLW legacy waste consisted of lab trash. LLW lab trash alone comprised 57% of all legacy LLW. Consequently, the disposition of the legacy lab trash was a priority of the project.

Nearly all of the MLLW/LLW waste had been shipped offsite for final disposition by the end of FY2005. On November 30, 2005, the Head of the LLNL Environmental Protection Department (EPD) notified the LSO Assistant Manager for Environmental Stewardship that the Legacy Waste Project had been completed (Raber, 2005).

3.2.1.3 End-State Requirements and Completion

The end state with respect to wastes is the disposition of the inventory of legacy wastes at LLNL. This was achieved on November 30, 2005 when the final shipment departed LLNL.

The letter from LLNL EPD to LSO (Raber, 2005) identified several processes that validated and verified project completion. These included consistent project documentation in regards to budgets and costs associated with container handling, tracking, and shipping documentation (e.g., Hazardous Waste Manifests, bill of ladings, waste profiles, LLNL shipping notification documents, invoices, etc.). Further validation of completion was also accomplished by project oversight through regularly scheduled meetings with all involved parties to ensure that work processes were in accordance to project baselines and ensuring that corporate goals were being met.

For TRU wastes, validation of completion was achieved by documentation and acknowledgement of receipt of the TRU waste shipments at the final disposition site, Waste Isolation Pilot Plant (WIPP), near Carlsbad, New Mexico.

In addition, the LSO completed field observations to further validate that no LWP waste containers remained in any LLNL storage areas. Field observations resulted in no findings of LWP containers in LLNL storage areas.

4. Engineered Controls, Operation and Maintenance Requirements, and Emergency/Contingency Planning

4.1. Engineered Controls

Treatment facility locations are shown on Figure 4. The treatment facility designs were documented and approved in the Remedial Design Reports (Bogel et al., 1993; Berg et al., 1993; Berg et al., 1994a; Berg et al., 1994b; Berg et al., 1995; Berg et al., 1998). Changes to the

designs are documented in regulatory-approved Explanations of Significant Differences (Dresen et al., 1993b; Berg et al., 1997a; Berg et al., 1997b; Berg et al., 2000). Treatment facility performance is documented in quarterly reports to the regulatory agencies. All treatment facilities operate in compliance. When issues occur, they are rectified as soon as possible, and the Regional Water Quality Control Board is quickly notified. All compliance issues and resolutions are discussed at the Remedial Project Manager's meetings and documented in the meeting summary, as well as the Annual Report for the stakeholders. Two CERCLA Five-Year Reviews (Berg et al, 1997c; Berg et al, 2002) have been conducted and have concluded that the remedy is functioning as intended and is protective of human health and the environment. The next Five-Year Review is in 2007.

At the transition to NNSA, the LLNL Livermore Site ground water remediation project will be operating and maintaining 27 ground water and 9 soil vapor extraction and treatment systems. One additional ground water facility will be relocated and start operation in FY 2007, as discussed in Section 3.1.1.3. The legacy waste project already transitioned in FY 2006.

As described in the *End State Vision for Lawrence Livermore National Laboratory, Livermore Site* (DOE, 2005), soil vapor extraction, ground water extraction, and institutional controls create exposure barriers to potential receptors (Fig. 12). The soil vapor extraction barrier is currently effective for on site exposure, and ongoing monitoring of the soil vapor extraction systems will ensure continued effectiveness of the control. The ground water extraction barrier is currently effective for both onsite and offsite exposure. Although some new facilities will be constructed in Long-Term Stewardship, these are designed to optimize the existing barriers and shorten time to cleanup. Ongoing monitoring of the ground water extraction systems will ensure continued effectiveness of the control. These controls will continue into Long-Term Stewardship and will be the responsibility of NNSA.

4.2. Exit Criteria

Exit criteria for the LLNL Livermore Site cleanup (i.e., the point when ground water remediation activities will be considered complete) is to (1) reduce contaminant concentrations in ground water to levels below MCLs, and (2) prevent migration in the unsaturated zone of those contaminants that would result in concentrations in ground water above an MCL. This is currently projected to occur in 2077. At that time, NNSA will file a petition for delisting of the site from the National Priorities List.

4.3. Operation and Maintenance

The following requirements are ongoing in Long-Term Stewardship and are part of the costs summarized in Section 7.2:

- Operating and maintaining about 28 ground water and 9 soil vapor extraction and treatment systems at the Livermore Site (as discussed in Section 3.1.1.3, one facility was moved in FY 2006 at the request of the institution for an upcoming construction project. This facility will be moved to a new location in FY 2007 and will increase the number of operating ground water facilities from 27 to 28).

- Monitoring the performance of extraction and treatment systems to ensure compliance with operating and discharge requirements.
- Improving the efficiency of the extraction and treatment systems and evaluating new technologies to optimize the cleanup.
- Performing modeling and hydrogeologic evaluations to estimate future contaminant concentrations and risk to human health and the environment, optimize remediation, and evaluate the effectiveness of cleanup.
- Conducting periodic monitoring of ground water, soil vapor, and ambient air to assess the progress of cleanup and ensure that human health and the environment are protected during cleanup.
- Maintaining the environmental restoration database system.
- Continuing administrative/institutional controls, land use restrictions, and the risk management program until cleanup standards are achieved.
- Continuing interactions with the regulatory agencies and the community.
- Meeting reporting requirements, including maintaining the official Administrative Record and submitting compliance monitoring and Five-Year Review reports.
- Documenting cleanup completion and deletion of the site from the CERCLA National Priorities List.

4.4. Emergency/Contingency Planning

Emergency/contingency planning for the post-closure activities is in place and is incorporated into LLNL's Integrated Safety Management System.

Uncertainties associated with the project are described and managed as outlined in the CERCLA *Contingency Plan* (McKereghan et al., 1996) and the *Risk Management Plan for Environmental Restoration, Lawrence Livermore National Laboratory* (DOE, 2006). The uncertainties described include technical issues (additional contaminant identification, change in technologies, failure of controls, etc.) as well as logistical issues (changes in regulatory requirements, funding issues, changes to the mission and operation of LLNL Livermore Site, etc.).

Worker safety is outlined in the Environment, Safety & Health (ES&H) Manual. The ES&H Manual is a compilation of ES&H-related requirements and policy information. The requirements in the ES&H Manual are based on the Work Smart Standards (WSS) identified for the specific work and associated hazards and environmental aspects, and LLNL best practices. The manual is accessed internally to LLNL workers on the website:

http://www-r.llnl.gov/es_and_h/esh-manual/volume1.html

LLNL has an emergency preparedness and response planning process as outlined in Volume II of the ES&H Manual (http://www.llnl.gov/es_and_h/hsm/doc_22.01/doc22-01.html#1.0). The plan is based on the hazards and potential consequences associated with each facility and its operation. The Laboratory uses the Incident Command System, in accordance with the California Standardized Emergency Management System (SEMS) to respond to Operational

Emergencies and to mitigate resulting consequences. The ES&H Manual describes the LLNL Emergency Management System and personnel responsibilities during Operational Emergencies that occur on LLNL property and those that take place offsite but could have a potential impact on LLNL.

5. Institutional Controls, Real and Personal Property, and Enforcement Authorities

5.1. Land Use and Institutional Controls

Current LLNL property land use is restricted by the site remaining a secured DOE facility. This restriction is anticipated for the foreseeable future. Fencing around the site perimeter controls access to the site. The local water purveyor controls water supply well installation off site. No additional controls are needed on site to prevent exposure to the ground water contaminants. A detailed discussion of the community and land use of the surrounding area is presented in the *Final Site-Wide Environmental Impact Statement for Continued Operation of the Lawrence Livermore National Laboratory and Supplemental Stockpile Stewardship and Management Programmatic Environmental Impact Statement* (NNSA, 2005).

5.2. Property Records

The site will remain under the jurisdiction of NNSA for the foreseeable future and does not require the transfer of property, personal property, and government furnished property.

Any facilities that are listed as "EM" property in the FIMS (Facilities Information Management System) database will need to be changed to "NNSA" property. The FIMS database is managed at Headquarters and requires a request from the Program Secretarial Officer (PSO) for any changes to be made.

6. Regulatory Requirements and Authorities

Regulatory requirements and pertinent regulatory documents are discussed below.

6.1. Decision Documents

The Livermore Site project decision documents are shown below:

- Primary documents:
  - — Federal Facility Agreement (1998).
  - — Record of Decision (DOE, 1992).
  - — Remedial Action Implementation Plan (Dresen et al., 1993a).
  - — Remedial Design Report 1 (Boegel et al., 1993).
  - — Remedial Design Report 2 (Berg et al., 1993).

  - — Remedial Design Report 3 (Berg et al., 1994a).
  - — Remedial Design Report 4 (Berg et al., 1998).
  - — Remedial Design Report 5 (Berg et al., 1995).
  - — Remedial Design Report 6 (Berg et al., 1994b).
  - — Compliance Monitoring Plan (Nichols et al., 1996).
  - — Contingency Plan (McKereghan et al., 1996).
  - — Five-Year Reviews (Berg et al., 2007; Berg et al., 2002).
  - — Explanations of Significant Differences (Dresen et al., 1993b; Berg et al., 1997a; Berg et al., 1997b; Berg et al., 2000).
- Standard Operating Procedures (EPA approved).
- DOE agreements at Remedial Project Manager's meetings.

All environmental regulations will remain in effect when the project is transferred from EM to NNSA.

6.2. Remedy

In the early 1980s, ground water contamination was discovered on and off site, which eventually resulted in the site being added to the National Priorities List (NPL) in 1987. A Federal Facility Agreement was signed among the DOE, the U.S. EPA, the California Regional Water Quality Control Board — San Francisco Bay Region (RWQCB), and the Department of Toxic Substances Control (DTSC). DOE is the lead agency for environmental restoration at LLNL. The lead regulatory agency for the Livermore Site is the EPA. A CERCLA Remedial Investigation and Feasibility Study were conducted in the early 1990s. The final remedy was agreed upon by DOE, the regulatory agencies, and the local community as codified in the ROD (DOE, 1992) and the schedule for remedy implementation was documented in the Remedial Action Implementation Plan (Dresen et al., 1993a).

The remedy for ground water involves extraction, piping water to a treatment system, treatment, and discharge of the treated water. The remedy for soil vapor involves extraction, piping vapor to a treatment system, treatment, and discharge of treated vapor. Remedies are phased-in to determine the actual effectiveness, compared to the predicted effectiveness of the initial planned extraction wells and treatment systems.

6.3. Five-Year Review

Two CERCLA Five-Year Reviews (Berg et al., 1997c; Berg et al., 2002) have concluded that the remedy is functioning as intended and is protective of human health and the environment. Follow up actions from the last Five-Year Review are completed or part of ongoing activities. The next Five-Year Review is in 2007. The EPA will also conduct a preliminary close out review of the site in FY 2007 to ensure all the buildout requirements have been met.

6.4. Regulatory Requirements

The Livermore Site project is required to comply with the regulatory drivers shown below:

- Comprehensive Environmental Response Compensation and Liability Act of 1980 as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA).
- 40 Code of Federal Regulations (CFR) 300 National Oil and Hazardous Substances Pollution Contingency Plan.
- 40 CFR 141.11-141.16, 141.50-141.51, Federal Safe Drinking Water Act regulations.
- 42 USCA 7401-7642, 40 CFR 50-69, Clean Air Act and implementing regulations.
- 40 CFR 264.601-602, Resource Conservation and Recovery Act of 1976 (RCRA) regulations.
- 33 USCA 1251-1376, Clean Water Act.
- 40 CFR 122-125 National Pollutant Discharge Elimination System.
- 29 CFR 1901.120, Occupational Safety and Health Administration (OSHA) and CCR Title 8, Cal-OSHA regulations.
- 10 CFR 1020, National Environmental Policy Act.
- State Water Resources Control Board (SWRCB) Resolution 92-49, Policies and Procedures for Investigation and Cleanup and Abatement of Discharges Under Water Code Section 13304.
- SWRCB Resolution 88-63, Sources of Drinking Water Policy.
- SWRCB Resolution 68-16, Anti-degradation Policy.
- California Health and Safety Code Section 2549.5, California Safe Drinking Water Act.
- WC13000-13806, Porter-Cologne Water Quality Control Act as administered under CCR Title 23, Subchapter 15, Section 1050-2836.
- Water Quality Control Plan (Basin Plan) for the San Francisco Bay Regional Water Quality Control Board.

The LLNL Livermore Site is on the National Priorities List (NPL) and is anticipated to remain on the NPL until the cleanup goals are achieved and NNSA petitions for delisting. The cleanup goals for all contaminants originating at the Livermore Site are:

- To prevent future human exposure to contaminated ground water and soil.
- To prevent further migration of contaminants in ground water.
- To reduce contaminant concentrations in ground water to levels below MCLs, and reduce the contaminant concentrations in treated ground water to levels below state discharge limits.
- To prevent migration in the unsaturated zone of those contaminants that would result in concentrations in ground water above an MCL.

- To meet all existing permit discharge standards for treated water and soil vapor, and to treat vapor so that there are no measurable atmospheric releases from treatment systems.

6.5. NRC License

U.S. Nuclear Regulatory Commission licenses are not applicable to this EM project.

6.6. Document Maintenance

All data, documents, or correspondence that make the body of documents that form the basis of selecting a CERCLA response action are required to be maintained in the Administrative Record (40 CFR 300.800-300.825). Items maintained in the Administrative Record include final reports, technical and site-specific information. The Administrative Record is a compilation of information considered in making site decisions. Under CERCLA, the lead agency is required to maintain the Administrative Record. Currently DOE has the lead responsibility for CERCLA response actions pursuant to Executive Order 12580. The Livermore Site Administrative Record is currently maintained by the LLNL Livermore Site project contractor, and is anticipated to remain so for the foreseeable future.

Documents are also kept at the LLNL repositories for public viewing. One repository is located at the Livermore Public Library, 1000 South Livermore Avenue. A second repository is at the LLNL Discovery Center on Greenville Road. The repositories will be maintained after the transfer to NNSA.

Core collected from CERCLA-drilled boreholes is kept in the Core Storage Library on site, as well as the detailed borehole field logs. Soil and water data are collected and stored in LLNL-managed database.

7. Budget, Funding, and Personnel Requirements

Remediation activities and resource requirements are discussed below.

7.1. EM's Environmental Remediation Activities

7.1.1. Life-Cycle Costs

The Life-Cycle Cost estimate for the soil and ground water remediation from FY 1997-2006 is $122.92 million. This project supports EM's strategic goal of protecting the environment by providing a responsible resolution to the environmental legacy of the Cold War. The remediation strategy for the Livermore Site employs a prioritized approach with an emphasis on risk reduction. The following priorities govern the scope of work for the cleanup project at LLNL Livermore Site:

- Western plume capture.
- Southern plume capture.

- Internal source control/mass removal.

The work scope of this project is based on codified cleanup remedies identified in regulatory decision documents. The scope of work will require the following remedies, many of which are already implemented and/or constructed and installed to meet operational and functional performance requirements:

- Ground water extraction, treatment, and discharge.
- Soil vapor extraction, treatment, and discharge.
- Monitoring.

These remedies will include the following activities:

- Operation and maintenance of ground water and soil vapor treatment systems.
- Continued regulatory interactions and compliance and community interface.
- Soil vapor and ground water monitoring and wellfield operations and maintenance.
- Modeling and hydrogeologic evaluation to estimate future contaminant concentrations and risk to human health and the environment, optimize remediation, and evaluate the effectiveness of cleanup.
- Maintaining administrative/institutional controls and the risk management program to prevent exposure until cleanup standards are achieved.
- Meeting reporting requirements including maintenance of the administrative record, submittal of compliance monitoring reports, and the Five-Year Reviews.
- Maintaining the data information system that is required to support planning, collection, tracking, verification, validation, reporting, interpretation, and use of data.
- Program management.

The project will result in the installation and construction of an operational and functional remediation system according to regulatory decision documents to meet codified remediation objectives.

7.1.2. Master Schedule of Ongoing Activities

A master schedule of ongoing activities is documented in ERD's Phoenix database as part of the annual baseline submittal and also in the PERM tool. Table 3 shows the decrease in facility operation, permits, and reports over the life-cycle of the project. New model results will be included into the PERM tool in FY 2007, which will better define individual treatment facility shutdown timeframes and cessation of operation and maintenance costs.

7.1.3. Required Resources

The current staff level and FY 2006 budget of $14.55 million meets the resource needs to achieve EM Completion. The estimated Long-Term Stewardship costs for the Livermore Site are presented in Table 4. Currently, the project supports about 50 staff. This staff will transition into Long-Term Stewardship; however, project planning targets about 3% reduction annually

over the next 10 years. At that time, Long-Term Stewardship manpower levels will stabilize and the project will absorb the escalation rate.

7.2. NNSA's Long-Term Stewardship Activities

7.2.1. Baseline Document

Annual baselines are prepared for the LLNL Livermore Site project, and will continue to be prepared in the future. These baseline incorporate activity-based costing and estimates are based on prior experience of same or similar tasks.

Life-cycle costs include, but are not limited to, the following activities:

- Operating and maintaining ground water and/or soil vapor extraction and treatment facilities. Monitoring and optimizing the performance of these facilities is also included.
- Installing additional extraction and treatment.
- Long-term monitoring of soil vapor, ground water, and ambient air.
- Regulatory compliance and community relations.

7.2.2. Funding Requirements

Table 4 presents the estimated Long-Term Stewardship costs for the Livermore Site. A number of assumptions were used in generating these cost estimates, including:

- No new CERCLA-regulated contamination is discovered at LLNL.
- No changes in regulatory requirements affect current scope, schedule, or budget.
- Additional treatment facilities will be required in areas where the ongoing remedial design has identified such a need.

7.2.3. Personnel Requirements

No additional activities are anticipated that have not been addressed in the criteria established for Section 7.2.2. The requirements during Long-Term Stewardship will be similar to existing requirements, so current personnel will continue in their capacities when the project is transferred. Currently, the project supports about 50 staff. This staff will transition into Long-Term Stewardship; however, project planning targets about 3% reduction annually over the next 10 years.

7.2.4. Legacy Environmental Remediation Scope

Milestone-related construction will be completed by the end of FY 2006; however, some ancillary work for the FY 2006 milestones may not get completed and will transition into FY 2007. This ancillary work includes items such as repaving, painting, final soil disposition, and any construction site restoration. The cost for these activities is included in the FY 2006 scope. If this ancillary work is not completed by the end of FY 2006, the funds will carryover into FY 2007.

Any field construction conducted in Long-Term Stewardship will be for the purpose of enhancing the current wellfields to accelerate ground water cleanup and/or source area remediation to reduce NNSA's long term mortgage. No construction milestones have been designated by the regulators during Long-Term Stewardship.

8. Information and Records Management Requirements

Records are maintained according to CERCLA requirements and regulatory permits. Primary CERCLA documents are managed as discussed in Section 6.6. No changes to record management are foreseen after transfer to NNSA. However, any applicable requirements in the Long-Term Stewardship Information and Records Management Transition Guidance will be followed.

9. Public Education, Outreach, Information, and Notice Requirements

The Livermore Site Community Relations Plan (Anderson et al., 1993) is designed to establish two-way communication between DOE/LLNL and the members of the public. It is also designed to provide understandable and consistent information to community members.

9.1. Stakeholders

The project managers communicate regularly with the Livermore Site project office and the regulatory agencies. A current contact list is provided in Attachment 3 and is updated as needed. Regularly scheduled meetings are held with the Remedial Project Managers (RPMs) to discuss project status and issues. These are scheduled by the RPMs and include project contractors from the Livermore Site project. In addition, quarterly meetings are held with the Technical Assistance Grant participants and annual meetings are held with the Community Work Group. Additionally, LSO regularly meets with the Environmental Protection Department Head and the Environmental Restoration Division Leader and Deputy Division Leader.

9.2. Public and Community Information

Livermore Site project community-relations activities include communications and meetings with neighbors and local, regional, and national interest groups and other community organizations. Activities include public presentations, producing and distributing the Environmental Community Letter, maintaining the Information Repositories and the Administrative Record, conducting site tours, and responding to public and news media inquiries. Community questions are also addressed via electronic mail. Project documents, letters and public notices are posted on a public website at:

http://www-envirinfo.llnl.gov/

LLNL's public affairs manages all community and media requests.

9.3. Public Involvement Costs

Costs associated with the contract Project Manager to conduct quarterly Technical Assistant Grant and annual Community Work Group are included in the baseline.

10. Natural, Cultural, and Historical Resource Management Requirements

Natural and cultural resources are managed by the DOE/NNSA Livermore Site Office (LSO) through existing programs and the ISO 14001 Environmental Management System and are briefly described below.

10.1. Historic Resource Information

The National Historic Preservation Act (NHPA) applies to historically important places and to the preservation of prehistoric and historic resources of the United States. LLNL resources subject to NHPA consideration range from prehistoric archeological sites to remnants of LLNL's own history of scientific and technological endeavor. LLNL completed an inventory and assessment of places (prehistoric and historic, archaeological, and architectural) and recommended those that meet the statutory threshold of historic importance. LSO, in consultation with the State Historic Preservation Officer (SHPO), determined that five of LLNL's archaeological resources qualify for listing in the National Register of Historic Places. LSO, in consultation with the SHPO, also determined that five buildings, one object, and two historic districts at LLNL are eligible for listing in the National Register of Historic Places. With the inventory and assessment completed, LSO, the SHPO, and the Advisory Council on Historic Preservation (ACHP) have initiated discussions toward the development of a new programmatic agreement that would govern how these National Register properties will be managed.

10.2. Biological Resource Information

Requirements of the U.S. Endangered Species Act, the California Endangered Species Act, the Eagle Protection Act, the Migratory Bird Treaty Act, and the California Native Plant Protection Act are met as they pertain to endangered species, threatened species, and other special status species (including their habitats) and designated critical habitats that exist at the LLNL. Currently, the LSO consults with the U.S. Fish and Wildlife Service (USFWS) when activities have the potential to result in impacts to federally endangered or threatened species. Currently, a biological assessment is being revised and updated to include additional projects. Biological surveys and monitoring for special-status species is accomplished throughout the year and reported on through various means including the DOE required Annual Site Environmental Report.

11. Business Closure Functions, Contract Closeout or Transfer, and Other Administrative Requirements

11.1. Pending Litigation and Liabilities

There are no pending liabilities or litigation pertaining to EM funded work at this time.

11.2. Sub-Contract Closeout Actions

The current contract is a Management and Operation (M&O) contract with the University of California. Any existing subcontracts will remain in place until the next contract is awarded.

11.3. DOE Orders

The LLNL Livermore Site project currently complies with all DOE Order requirements and will continue to do so after the transition to NNSA. In accordance with Contract 48, Section I Clause entitled Laws, Regulation, and DOE Directives, the contractor will comply with all DOE directives in effect at the start of the contract. DOE Orders that apply to the site cleanup include:

- DOE Order 413.3, Program and Project Management for the Acquisition of Capital Assets
- DOE Order 414.1A, Quality Assurance
- DOE Order 5400.1, General Environmental Protection Program
- DOE Order 5480.4, Environmental Protection, Safety, and Health Protection Standards

In addition, the following Orders apply to environmental work in general:

- DOE Order 231.1, Environmental, Safety and Health Reporting
- DOE Order 232.1A, Occurrence Reporting and Processing of Operations Information
- DOE Order 435.1, Radioactive Waste Management
- DOE Order 450.1, Environmental Protection Program
- DOE Order 5400.5, Radiation Protection of the Public and the Environment

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Abbreviations/Acronyms

ACHP	Advisory Council on Historic Preservation
ARARs	Applicable or Relevant and Appropriate Requirements
CCP	Central Characterization Project
CBFO	Carlsbad Field Office
CD-4	Critical Decision 4
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CRD	Catalytic Reductive Dehalogenation
DOE	U.S. Department of Energy
DTSC	California Department of Toxic Substances Control
DWTF	Decontamination and Waste Treatment Facility
ELM	Eastern Landing Mat
EM	Environmental Management
EPA	U.S. Environmental Protection Agency
EPD	Environmental Protection Division
ERD	Environmental Restoration Division
ES&H	Environmental, Safety and Health
FFA	Federal Facility Agreement
FY	fiscal year
GAC	Granular Activated Carbon
GTU	GAC Treatment Unit
HSU	Hydrostratigraphic Unit
LLNL	Lawrence Livermore National Laboratory
LLW	Low Level Waste
LWP	Legacy Waste Project
LSO	Livermore Site Office
M&O	Management and Operation
MCL	Maximum Contaminant Level
MLLW	Mixed Low Level Waste
MTU	Miniature Treatment Unit

NRDA	Natural Resource Damage Assessment
NHPA	National Historic Preservation Act
NNSA	National Nuclear Security Administration
NPL	National Priorities List
NRC	Nuclear Regulatory Commission
OSHA	Occupational Safety and Health Administration
PCBs	polychlorinated biphenyls
PCE	perchloroethylene
PERM	Practical Environmental Restoration Management
PTU	Portable Treatment Unit
RCRA	Resource Conservation and Recovery Act
ROD	Record of Decision
RPM	Remedial Project Manager
RWQCB	California Regional Water Quality Control Board
SARA	Superfund Amendments and Reauthorization Act
SEMS	Standardized Emergency Management System
SHPO	State Historic Preservation Officer
SNL	Sandia National Laboratories
STU	Solar Treatment Unit
SWRCB	State Water Resource Control Board
TCE	trichloroethylene
TF	Treatment Facility
TF406	Treatment Facility 406
TF5475	Treatment Facility 5475
TF518	Treatment Facility 518
TFA	Treatment Facility A
TFB	Treatment Facility B
TFC	Treatment Facility C
TFD	Treatment Facility D
TFE	Treatment Facility E
TFF	Treatment Facility F
TFG	Treatment Facility G

TFH	Treatment Facility H
TRU	Transuranic Waste
USFWS	U. S. Fish and Wildlife Service
VES	Vapor extraction system
VOC	volatile organic compound
VTF406	Vapor Treatment Facility 406
VTF511	Vapor Treatment Facility 511
VTF518	Vapor Treatment Facility 518
VTF5475	Vapor Treatment Facility 5475
VTFE	Vapor Treatment Facility E
VTFD	Vapor Treatment Facility D
WIPP	Waste Isolation Pilot Plant
WSS	work smart standards

Figures

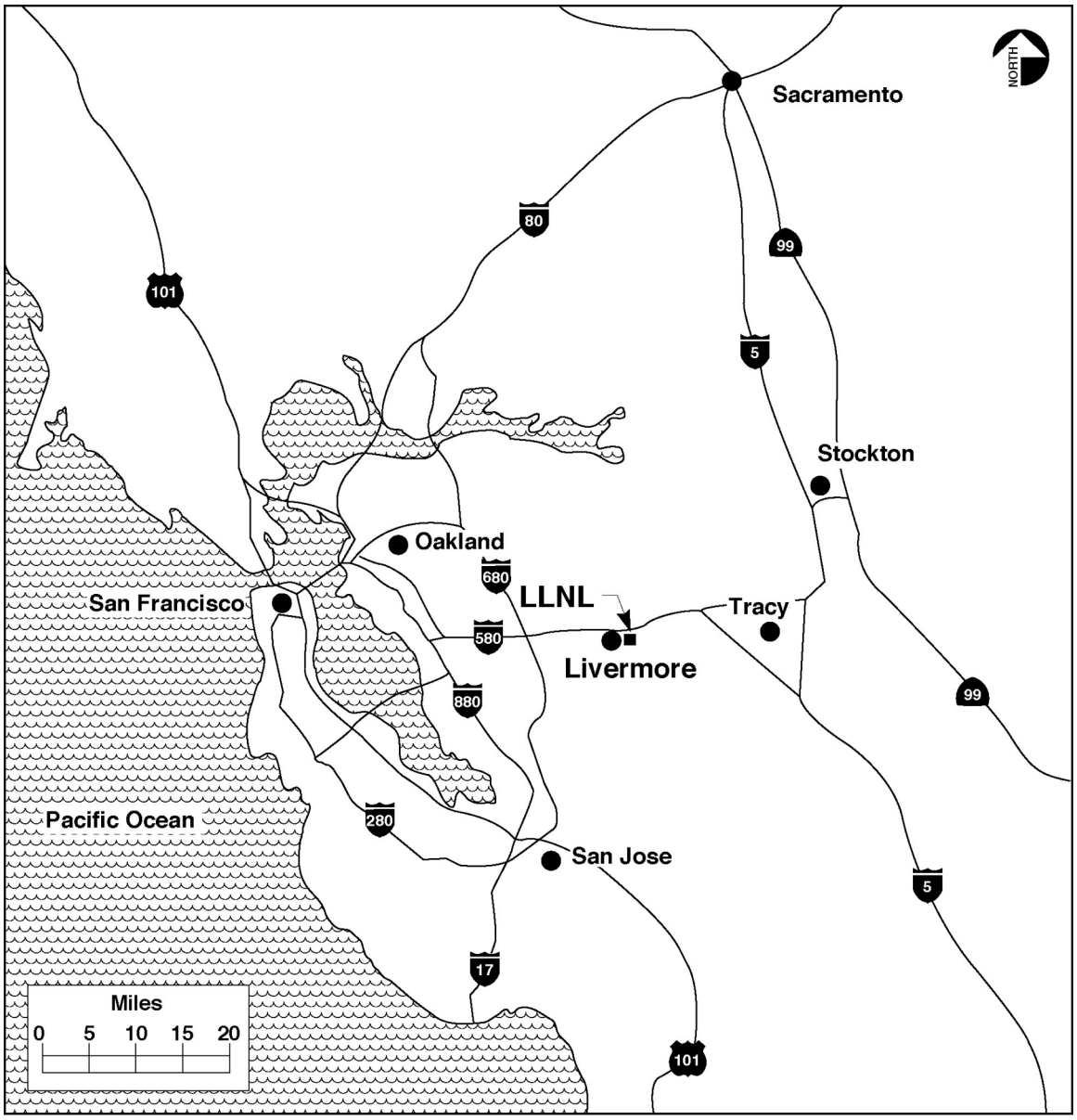

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Figure 1. Location of the LLNL Livermore Site.

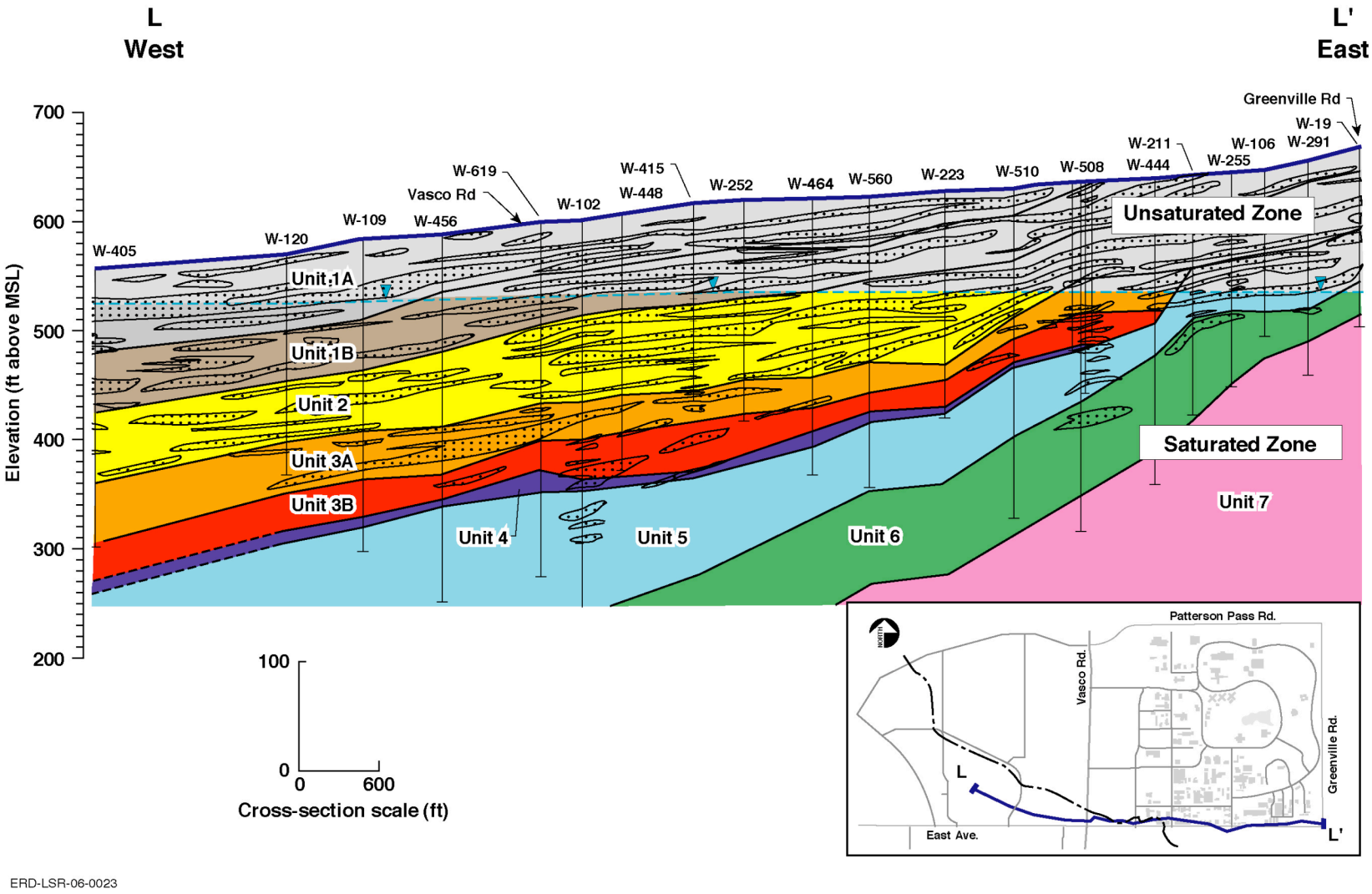

Figure 2. Hydrostratigraphic units at the Livermore Site.

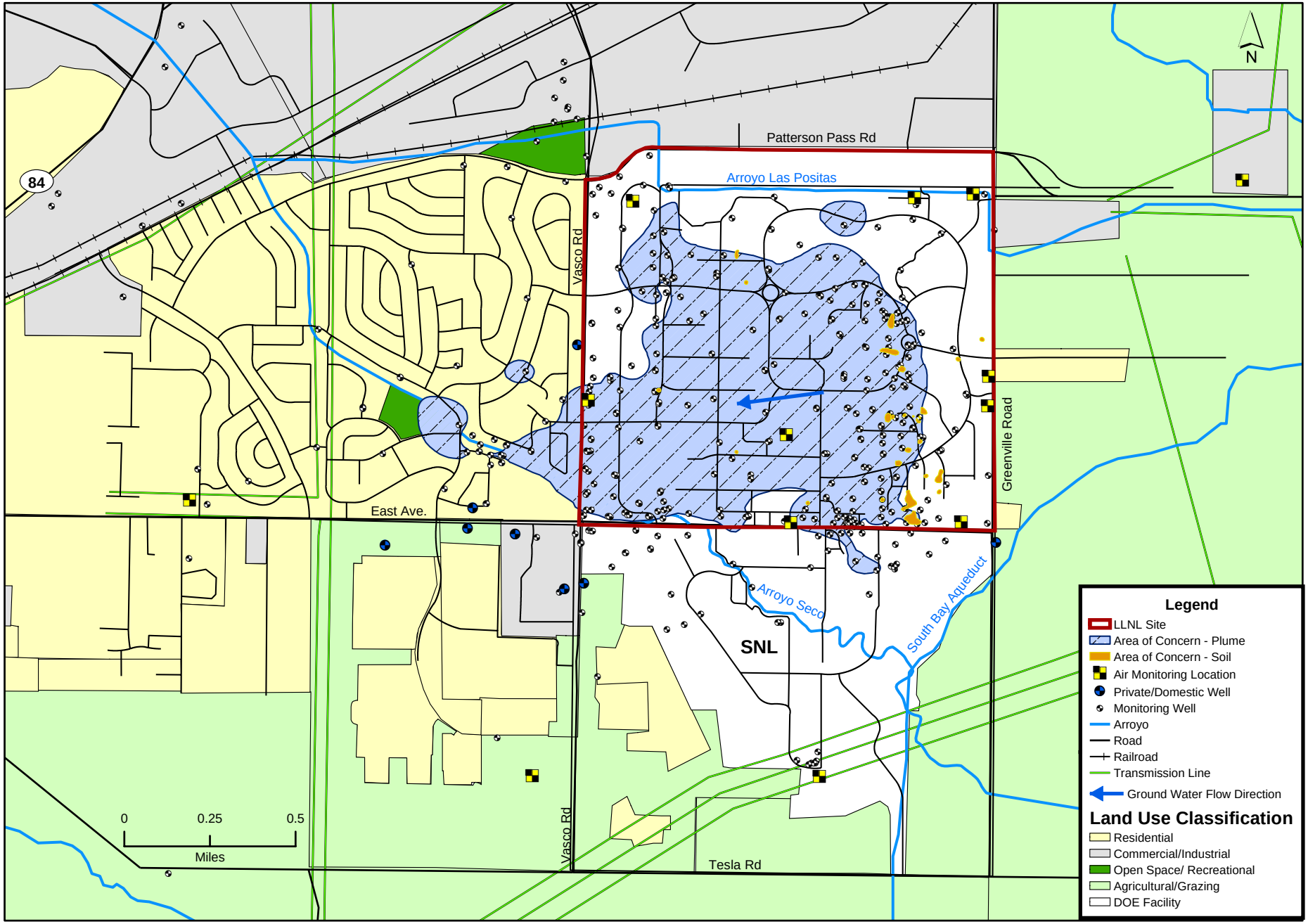

Figure 3. Extent of Livermore Site contamination and offsite land use.

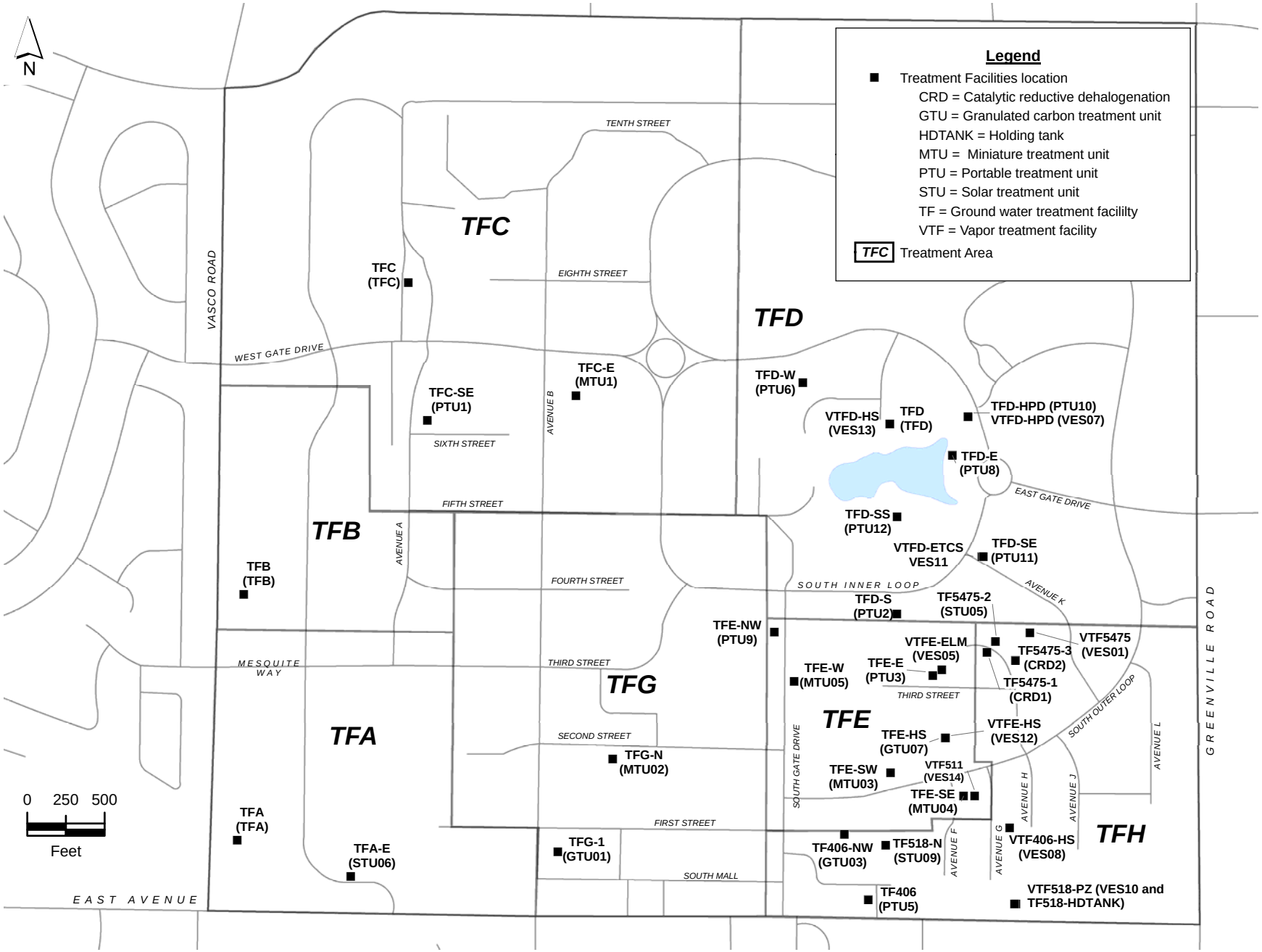

Figure 4. Livermore Site treatment areas and treatment facility locations.

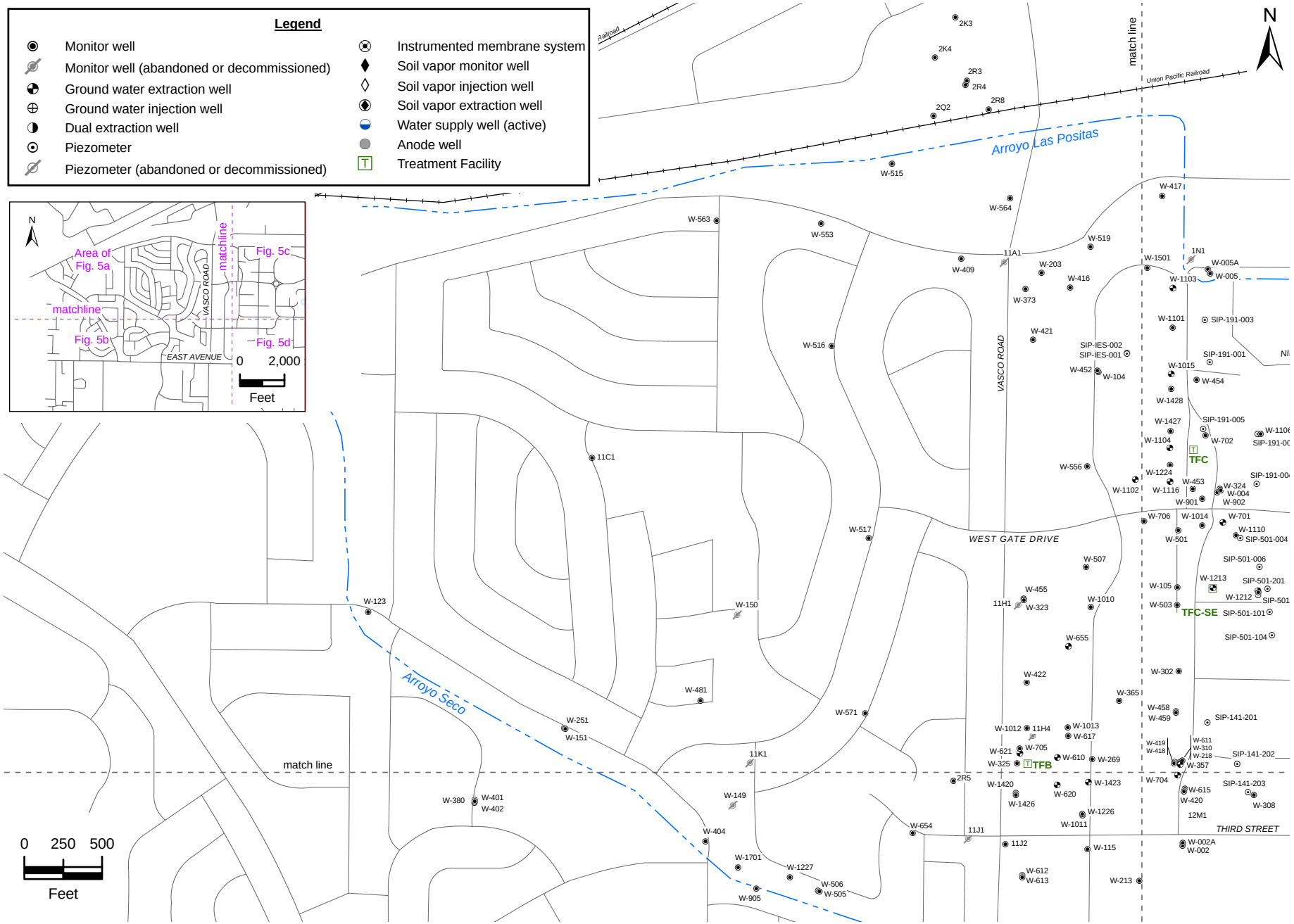

Figure 5a. Ground water wells at the Livermore Site.

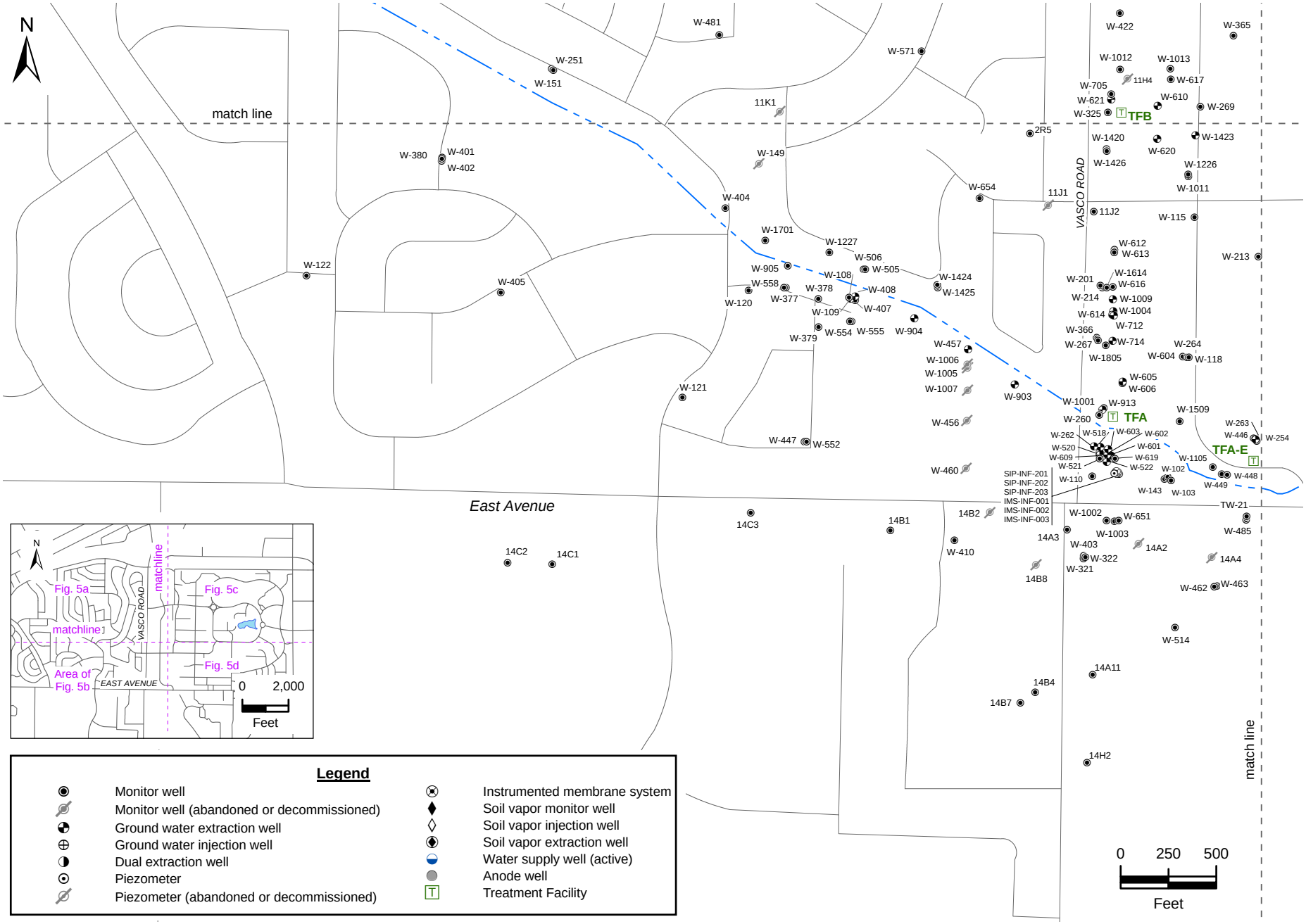

Figure 5b. Ground water wells at the Livermore Site.

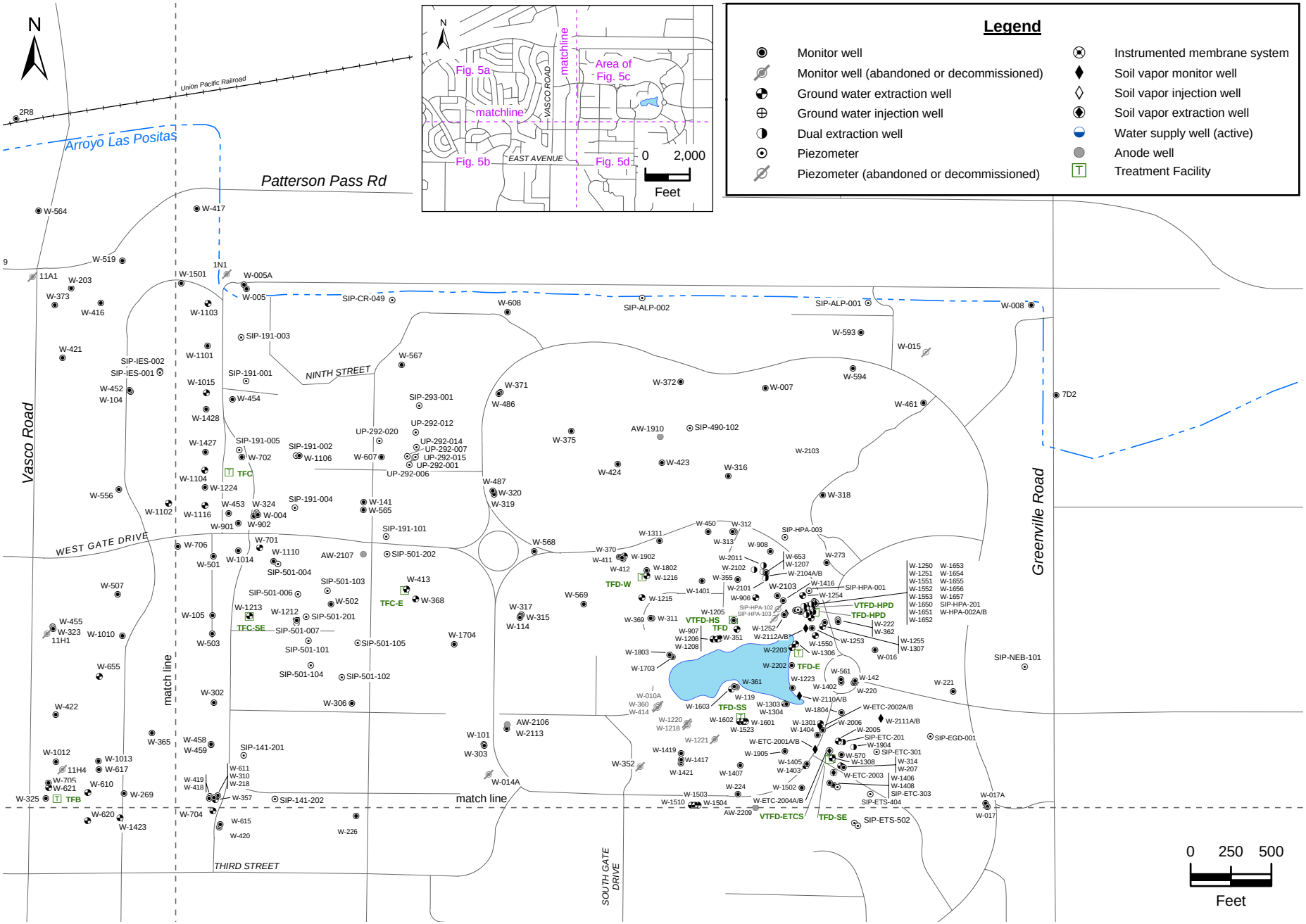

Figure 5c. Ground water wells at the Livermore Site.

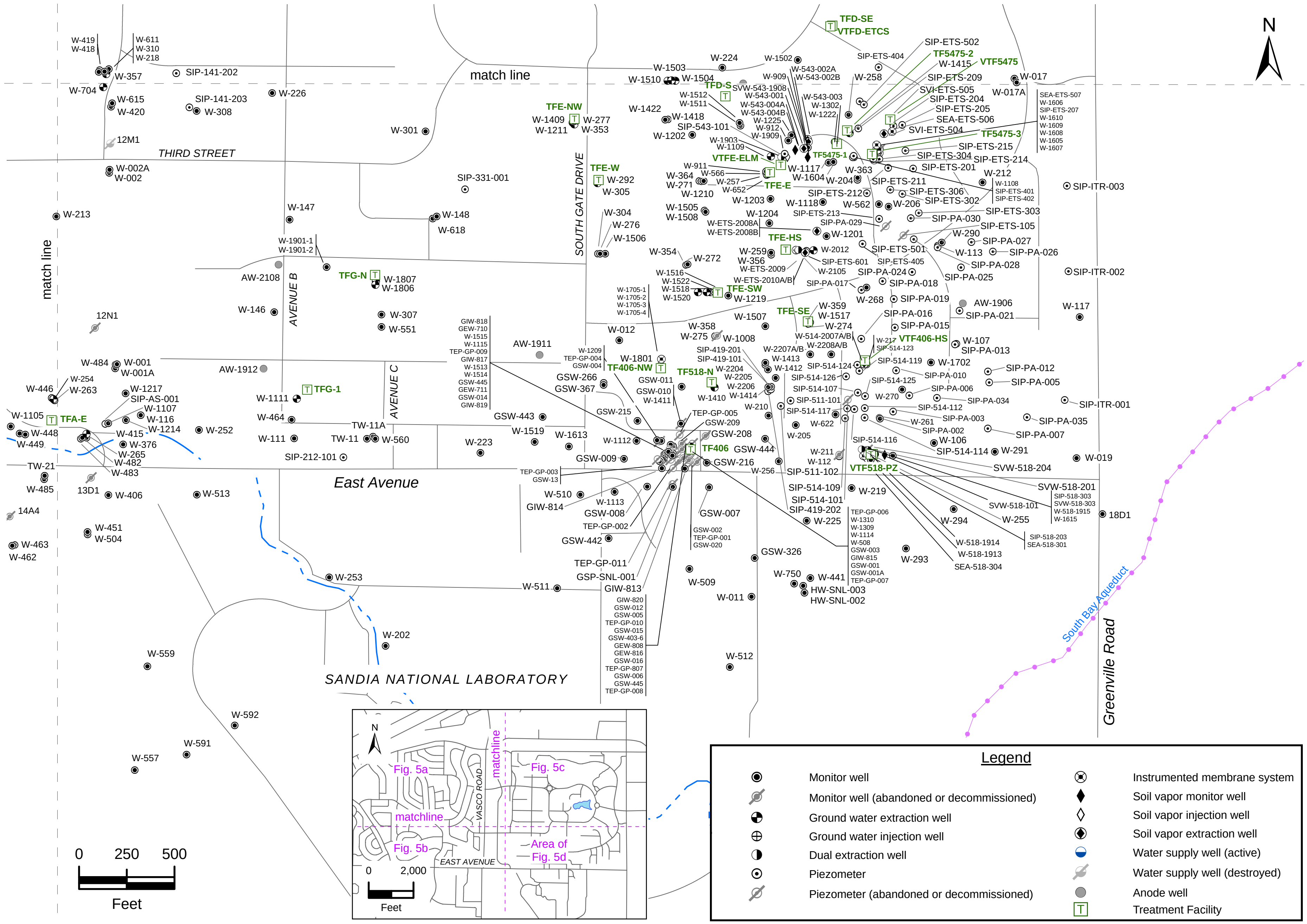

Figure 5d. Ground water wells at the Livermore Site.

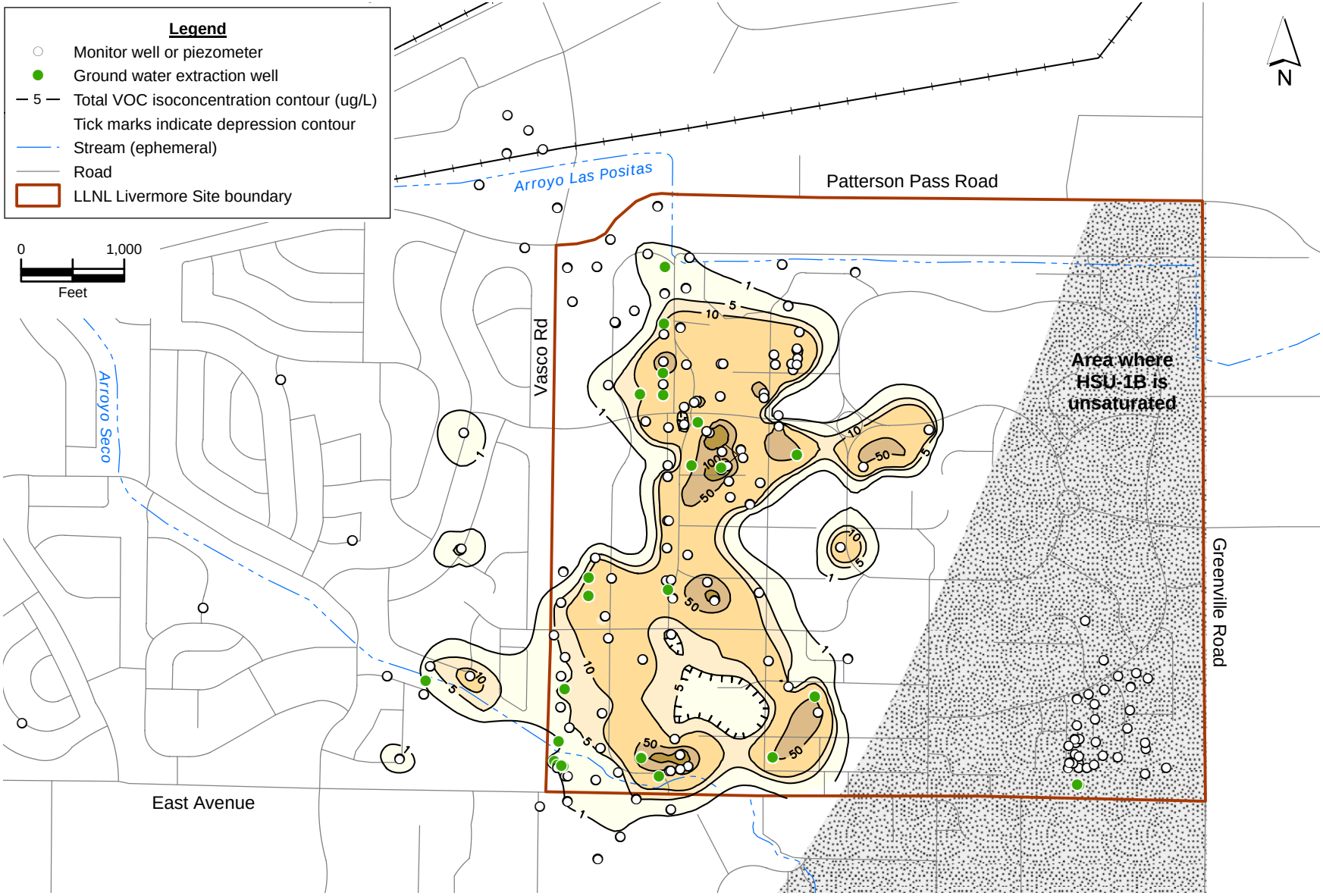

Figure 6. Isoconcentration contour map of total VOCs from 132 wells completed within HSU-1B, fourth quarter 2005 (or the next most recent data), and supplemented with soil chemistry data from 39 borehole locations.

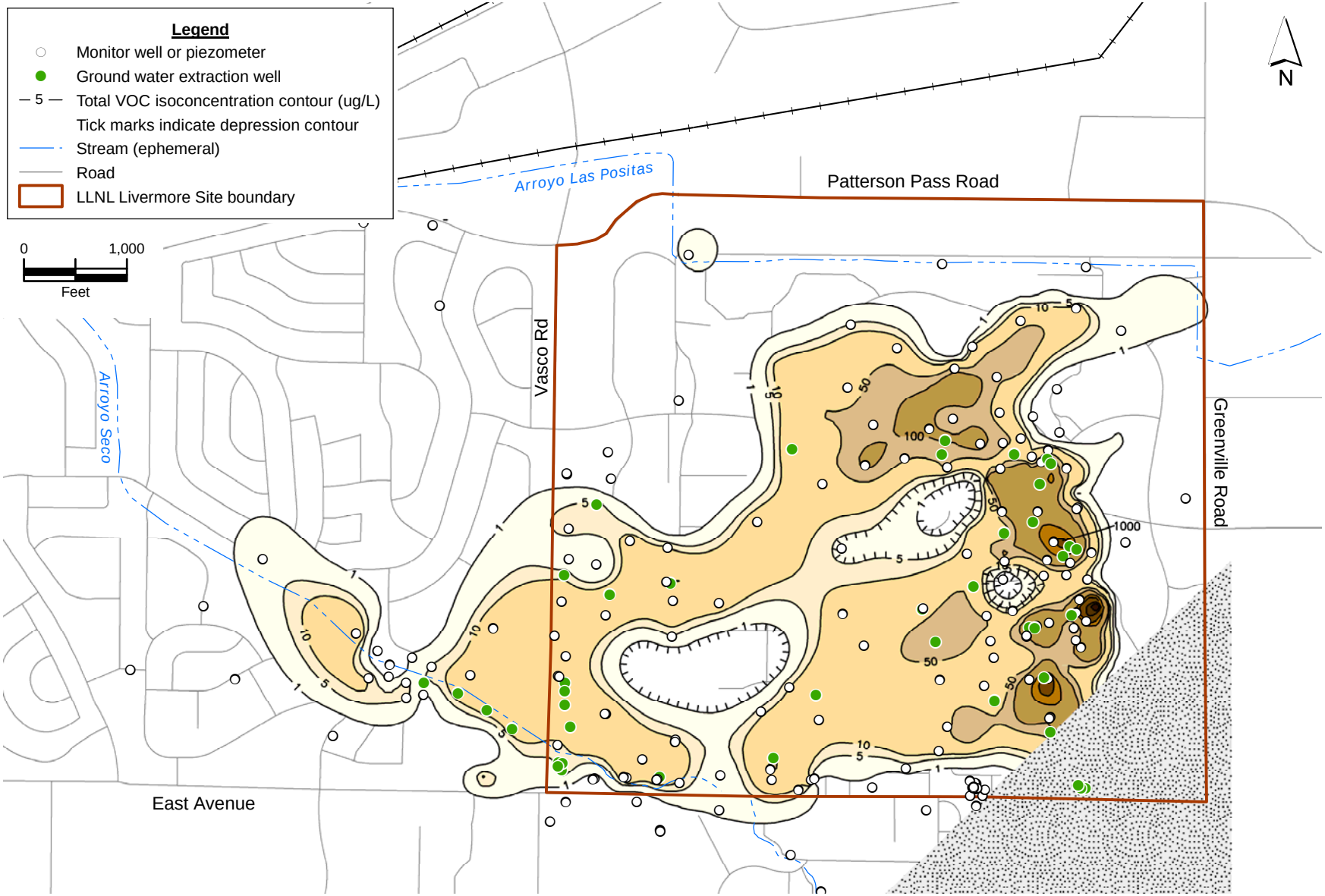

Figure 7. Isoconcentration contour map of total VOCs from 190 wells completed within HSU-2, fourth quarter 2005 (or the next most recent data), and supplemented with soil chemistry data from 66 borehole locations.

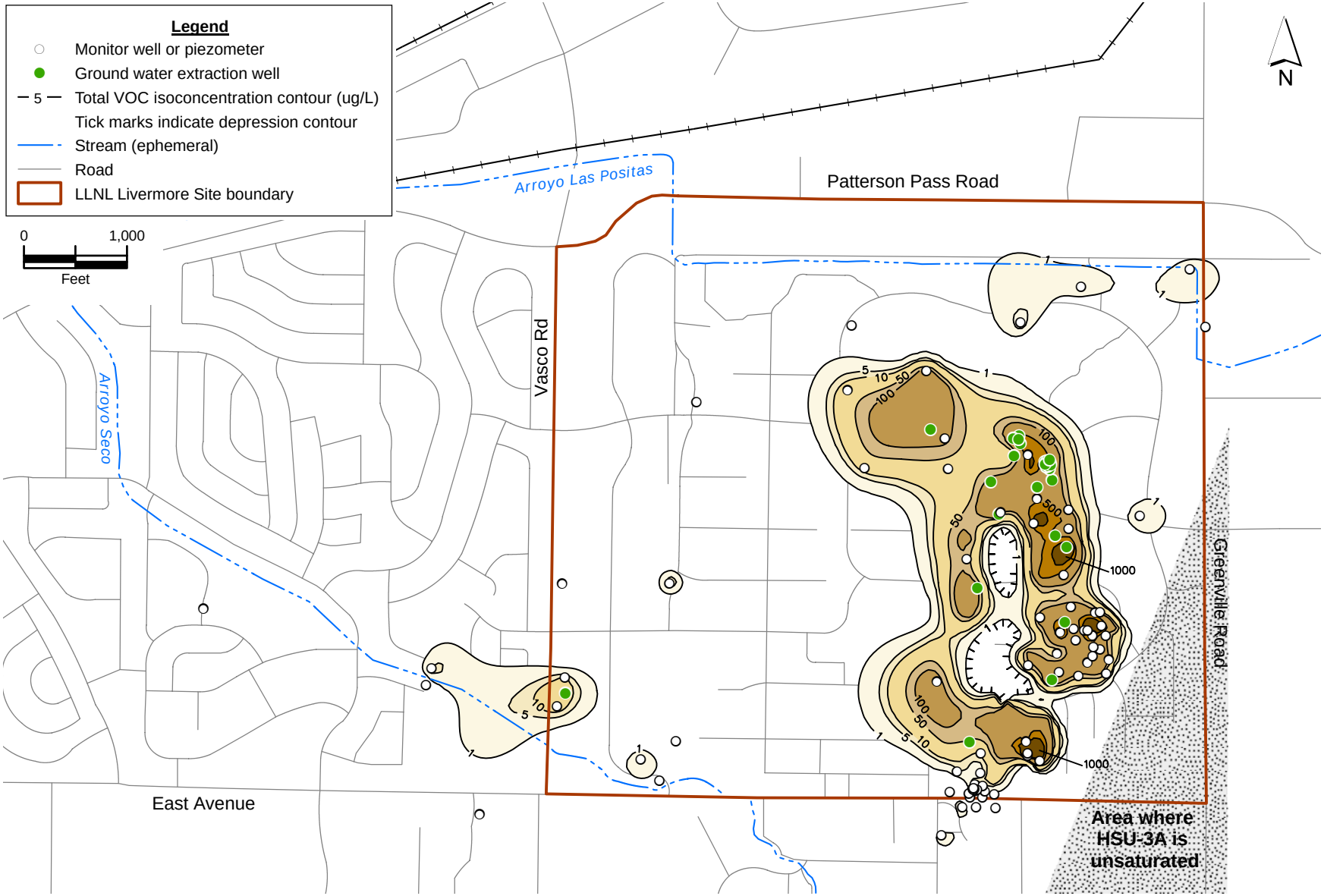

Figure 8. Isoconcentration contour map of total VOCs from 108 wells completed within HSU-3A, fourth quarter 2005 (or the next most recent data), and supplemented with soil chemistry data from 139 borehole locations.

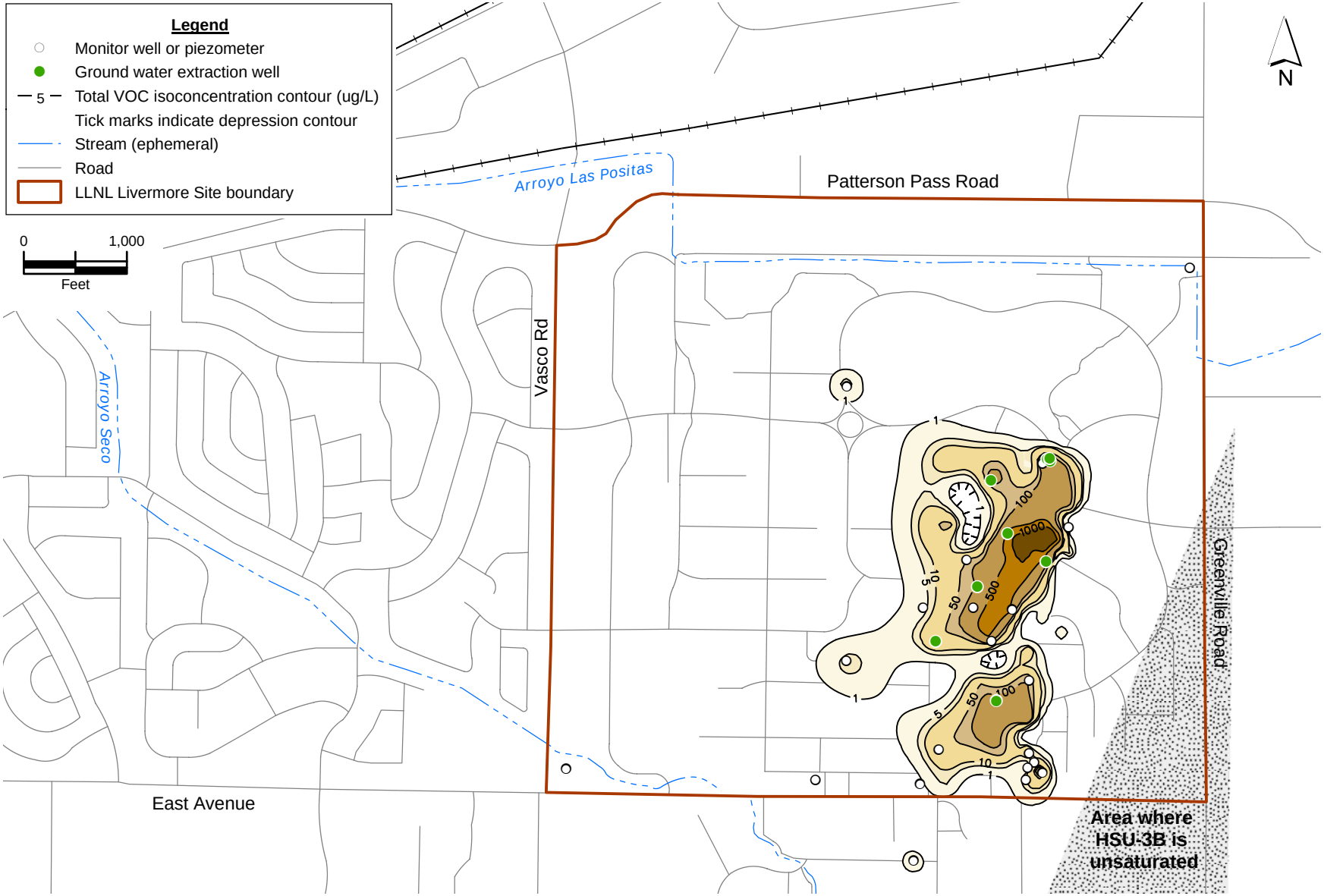

Figure 9. Isoconcentration contour map of total VOCs from 42 wells completed within HSU-3B, fourth quarter 2005 (or the next most recent data), and supplemented with soil chemistry data from 104 borehole locations.

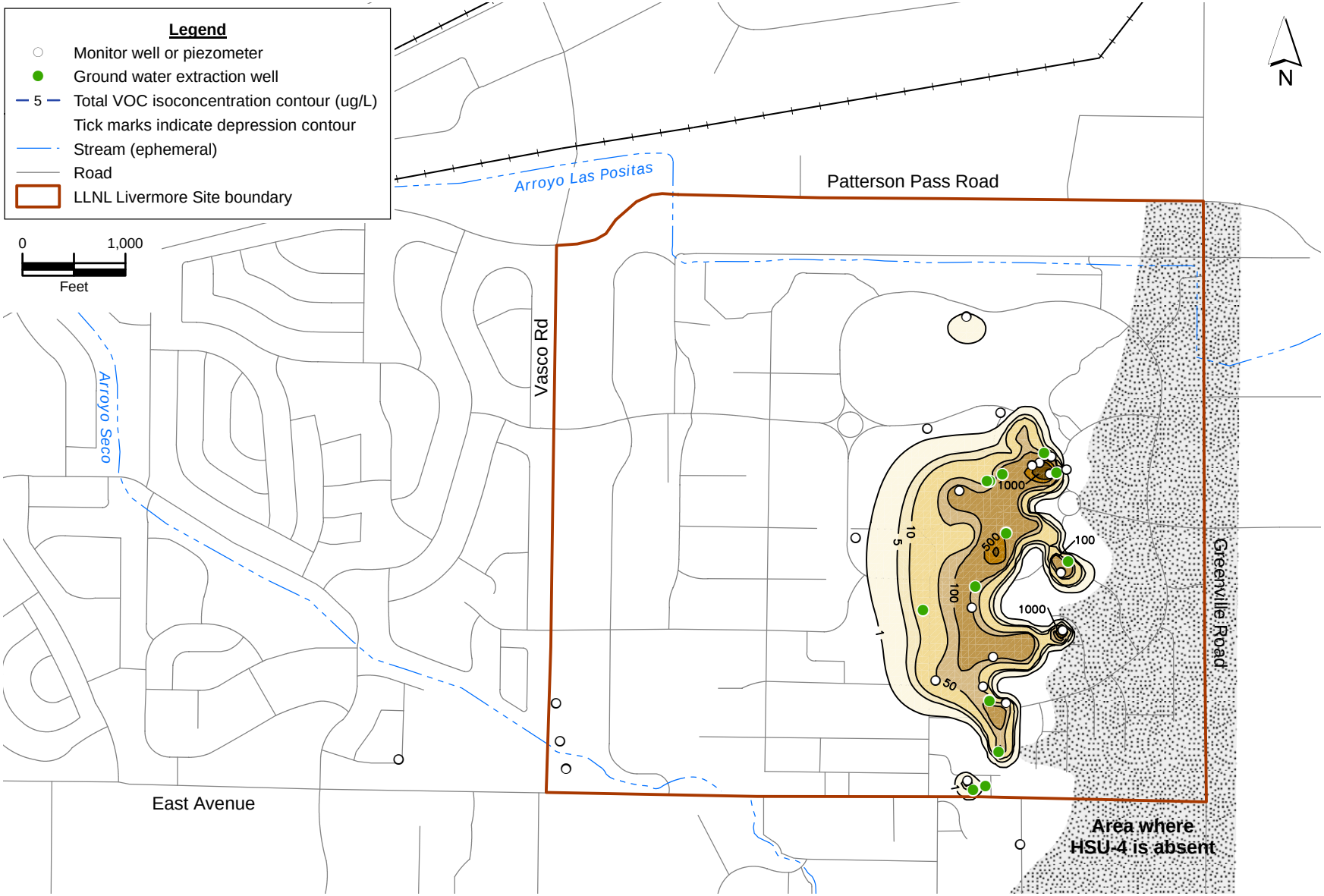

Figure 10. Isoconcentration contour map of total VOCs from 44 wells completed within HSU-4, fourth quarter 2005 (or the next most recent data), and supplemented with soil chemistry data from 51 borehole locations.

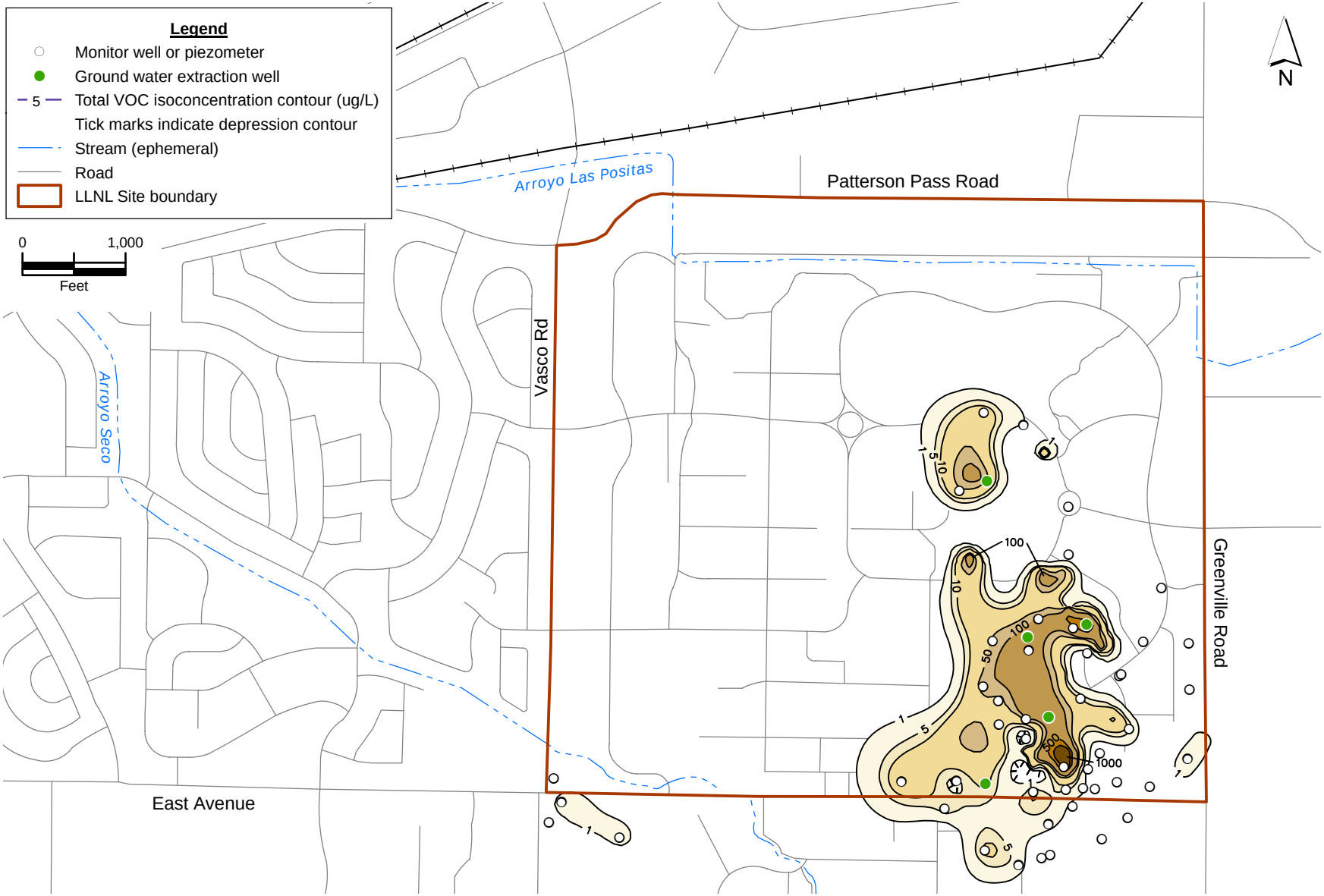

Figure 11. Isoconcentration contour map of total VOCs from 55 wells completed within HSU-5, fourth quarter 2005 (or the next most recent data), and supplemented with soil chemistry data from 94 borehole locations.

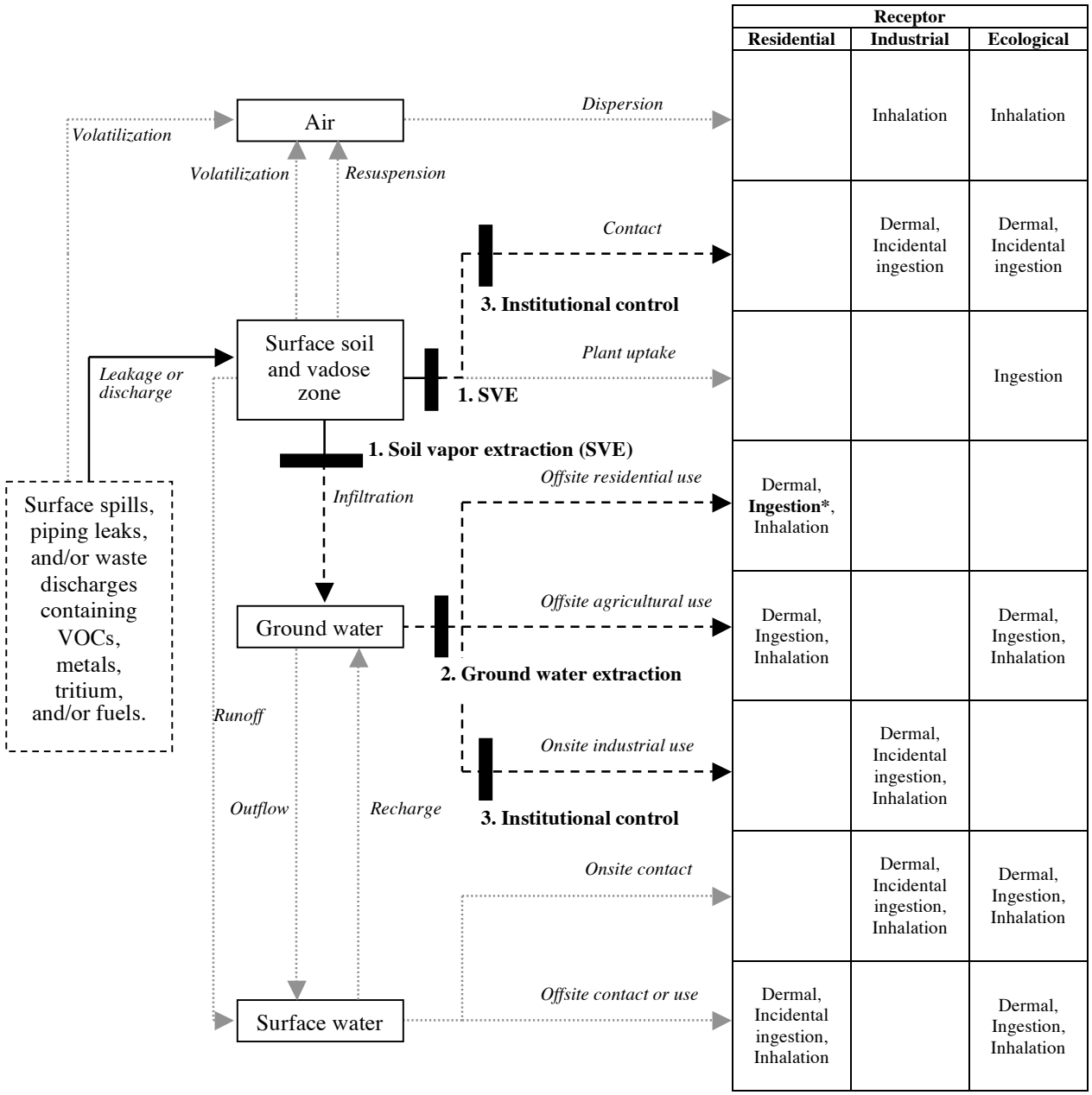

Figure 12. Livermore Site End-State Vision.

Tables

Table 1. Remediation standards for compounds of concern in ground water at the LLNL Livermore Site.

Constituent	Federal Maximum Contaminant Level[a]	California Maximum Contaminant Level[a]
PCE	5 ppb	5 ppb
TCE	5 ppb	5 ppb
1,1-DCE	7 ppb	6 ppb
cis-1,2-DCE	70 ppb	6 ppb
trans-1,2,-DCE	100 ppb	10 ppb
1,1-DCA	—	5 ppb
1,2-DCA	5 ppb	0.5 ppb
Carbon tetrachloride	5 ppb	0.5 ppb
Total THM[b]	100 ppb	100 ppb
Benzene	5 ppb	1 ppb
Ethyl benzene	700 ppb	680 ppb
Toluene	1 ppm	—
Xylenes (total)	10 ppm	1.75 ppm
Ethylene dibromide	0.05 ppb	0.02 ppb
Chromium	50 ppb	50 ppb
Lead	15 ppb	50 ppb
Tritium	—	20,000 pCi/L

Notes:

[a] MCLs from DOE (1992).

[b] Total trihalomethanes (THMs); includes chloroform, bromoform, chlorodibromomethane, and bromodichloromethane.

Table 2. Livermore Site Project Key Milestones.

Task	Milestone date	Completion date
Issue Remedial Action Implementation Plan	1-6-93	1-6-93
Begin operation of TFF	2-93	1-93
Issue RD1	4-12-93	4-12-93
Issue Revised Community Relations Plan	6-30-93	7-12-93
Issue RD2	9-10-93	9-10-93
Begin treatability study at Trailer 5475	9-30-93	9-30-93
Begin operation of TFC	10-30-93	10-29-93
Issue RD3	3-1-94	3-1-94
Begin operation of TFD	9-30-94	9-29-94
Issue RD6	11-30-94	11-22-94
Issue RD5	5-1-95	4-25-95
Begin operation of Building 518 vapor extraction system	9-29-95	9-25-95
Issue Compliance Monitoring Plan	1-29-96	1-25-96
Begin operation of TFG-1	4-18-96	4-17-96
Begin operation of TF406 PTU	8-30-96	8-27-96
Begin operation of TFE East PTU	11-27-96	11-25-96
Issue Contingency Plan	11-28-96	11-15-96
Begin operation of TFC Southeast PTU	1-31-97	1-21-97
Begin operation of TFD West PTU	4-25-97	4-22-97
First 5 Year Review	8-5-97	8-1-97
Begin operation of TFD East PTU	10-3-97	9-16-97
Issue RD4	1-30-98	2-12-98[a]
Begin operation of TF518 PTU	1-30-98	1-27-98
Begin operation of TFD Southeast PTU	3-27-98	3-27-98
Begin operation of TFE Northwest PTU	6-26-98	6-23-98
Begin operation of TF5475 CRD (Phase 1)	9-30-98	9-9-98
Begin operation of VTF5475 vapor extraction system	1-29-99	1-21-99

Table 2. Livermore Site Project Key Milestones. (Con't. Page 2 of 3)

Task	Milestone date	Completion date
Begin operation of TF5475 STU	3-31-99	3-18-99
Begin operation of TFD South PTU	6-29-99	6-23-99
Begin operation of STU-7	8-6-99	8-4-99
Begin operation of TF518 North STU	1-28-00	1-26-00
Begin operation of TFD Southshore MTU	3-31-00	6-30-00 [a]
Begin operation of TFE Southwest MTU	6-30-00	6-27-00
Begin operation of TF5475 CRD (Phase 2)	9-29-00	9-27-00
Begin operation of TFE Southeast MTU	1-31-01	3-19-00 [a]
Begin operation of TFE West MTU	4-30-01	4-26-01
Begin operation of TFD Marina Pipeline	7-31-01	7-25-01
Begin operation of TF5475 CRD (Phase 3)	9-28-01	9-19-01
Begin TFC East remediation	4-3-02	4-3-02
Begin TF406 Northwest remediation	7-31-02	7-16-02
Issue Five-Year Review	9-30-02	9-30-02
Begin TF5475 soil vapor extraction expansion	9-30-02	9-23-02
Begin TFC Northeast remediation	5-30-03	5-23-03
Begin TFG North remediation	7-31-03	7-28-03
Begin Eastern Landing Mat Source Area remediation	9-26-03	9-22-03
Begin Helipad Source Area remediation	9-30-04	6-8-04
Begin TF518 perched-zone remediation	9-30-04	9-3-04
Begin Southern East Traffic Circle Source Area remediation	9-30-05	7-13-02
Begin TFD Hotspot remediation	9-30-05	9-20-05
Begin TFE Hotspot remediation	9-30-05	8-23-05
Begin TF406 Hotspot remediation	9-30-05	8-30-05
Begin Northern East Traffic Circle Source Area remediation	9-29-06	8-2-06
Begin Building 419 Source Area remediation	9-29-06	TBD

Table 2. Livermore Site Project Key Milestones. (Con't. Page 3 of 3)

Task	Milestone date	Completion date
Begin TFC Hotspot remediation	**9-29-06**	**4-24-06**
Begin Buildings 511/514 Source Area remediation	**9-29-06**	**TBD**
Begin TF5475 South remediation	**9-29-06**	**6-6-06**

Notes:

All primary FFA documents will be submitted to DOE 30 days prior to submission to the regulatory agencies.

There were six phased Remedial Design (RD) submittals (RD1 through RD6).

Draft RD1 = TFA, TFB, and associated extraction wells and piezometers.

Draft RD2 = TFC, TFF, and associated extraction wells and piezometers.

Draft RD3 = TFD, TFE, associated extraction wells and piezometers, and Building 518 vapor extraction treatability study results.

Draft RD4 = Trailer 5475/East Taxi Strip Area.

Draft RD5 = TFG-1, TFG-2 (TFG Northeast), and associated extraction wells and piezometers.

Draft RD6 = Building 518 vapor extraction system.

PTU = Portable Treatment Unit.

CRD = Catalytic Reductive Dehalogenation.

MTU = Miniature portable Treatment Unit.

STU = Solar-powered Water Activated-carbon Treatment.

GTU = Granular activated-carbon Treatment Unit.

TBD = To be Determined (construction is in progress and on schedule)

[a] **Delayed with regulatory concurrence.**

Table 3. Schedule of Long-Term Stewardship Activities.

Description	FY06	FY07-10	FY11-15	FY16-20	FY21-30	FY31-40	FY41-50	FY51-60	FY61-70	FY71-80	Comments
Number of ER sites active at least one year during this timeframe	9	9	8	6	5	4	4	4	3	1	Livermore Site has one Operable Unit, but has been divided into 9 Subproject Areas.
# operating ground water fixed treatment unit	4	4	2	1	1	1	1	1	1	0	Includes facilities shutdown during this timeframe
# operating ground water solar-powered treatment units (STUs)	3	3	3	2	1	1	1	1	1	0	Includes facilities shutdown during this timeframe
# operating ground water portable treatment units (PTUs)	10	11	10	8	8	3	3	1	1	0	Includes facilities shutdown during this timeframe
# operating ground water granular activated carbon treatment units (GTU)	3	3	2	2	1	1	1	1	0	0	Includes facilities shutdown during this timeframe
# operating ground water Miniature Treatment Units (MTUs)	5	5	5	3	2	1	0	0	0	0	Includes facilities shutdown during this timeframe
# operating ground water catalytic reductive dehalogenation (CRD) treatment units	2	2	2	2	2	2	2	2	2	1	Includes facilities shutdown during this timeframe
# operating soil vapor treatment units	9	9	9	5	0	0	0	0	0	0	Includes facilities shutdown during this timeframe
Total # operating treatment units	36	37	33	23	15	9	8	6	5	1	
# Air Discharges permitted and monitored	29	29	26	17	11	5	4	2	2	0	Permits are discontinued as regulated treatment units are shut down. VTF5475 does not require a permit.
# Permit Substantive Requirements Followed for Treated Water Discharge	1	1	1	1	1	1	1	1	1	1	Permits are discontinued as regulated treatment units are shut down.
Total # discharges permitted and monitored	30	30	27	18	12	6	5	3	3	1	
# CERCLA-required Annual Reports submitted to regulatory agencies	1	4	5	5	10	10	10	10	10	7	
# CERCLA Five-Year Reviews	0	1	1	1	2	2	2	2	2	2	
# of Preliminary Closeout Reports	0	1	0	0	0	0	0	0	0	0	
# Quarterly Self-Monitoring Reports submitted to regulatory agencies	4	16	20	20	40	40	40	40	40	28	
Total # documents/reports submitted	5	22	26	26	52	52	52	52	52	37	

Notes:

CERCLA = Comprehensive Environmental Response, Compensation and Liability Act
CRD = Catalytic Reductive Dehalogenation for VOC contamination
ER = Environmental restoration
FY = Fiscal Year
GTU = Granular activated carbon treatment unit for VOC contamination
MTU = Miniature portable treatment unit for VOC contamination
PTU = Portable treatment unit for VOC contamination
STU = Solar powered treatment unit for VOC contamination
VOC = Volatile organic compound

Table 4. Long-Term Stewardship costs for the Livermore Site.

Fiscal Year(s)	Budget ($M)
2007	12.556
2008	11.432
2009	12.097
1010	11.290
1011	11.363
1012	11.300
1013	11.297
1014	11.128
1015	10.922
1016	10.735
1017	10.565
1018	11.040
1019	10.438
1020	9.644
2021-2025	46.899
2026-2030	47.065
2031-2035	47.695
2036-2040	47.688
2041-2045	46.218
2046-2050	47.433
2051-2055	48.715
2056-2060	46.561
2061-2065	42.339
2066-2070	35.612
2071-2075	27.978
2076-2077	9.753

Attachment 1
Livermore Site Treatment Facilities

Livermore Site Treatment Facilities

Figure 1. Treatment Facility A (TFA) started operation in April 1989 and was fully operational by September 1989. The facility was originally designed to treat volatile organic compounds in ground water by ultraviolet light/oxidation followed by air stripping. In June 1997 the technology was changed to air stripping only (Berg et al., 1997a).

Figure 2. Treatment Facility A East (TFA-E; STU06) started operation in August 1999 with a different unit than pictured above (Aarons et al., 2000). The facility removes volatile organic compounds from ground water using granular activated carbon.

Figure 3. Treatment Facility B (TFB) started operation in the summer of 1990, and was fully operational in October 1990. The facility was originally designed to treat volatile organic compounds in ground water by ultraviolet light/oxidation followed by air stripping. In July 1998 the technology was changed to air stripping only (Berg et al., 1997a).

Figure 4. Treatment Facility C (TFC) started operation in October 1993 (Hoffman et al., 1994). The facility removes volatile organic compounds from the ground water through air stripping and hexavalent chromium through ion-exchange.

Figure 5. Treatment Facility C East (TFC-E; MTU1) started operation in April 2002 (Dibley et al., 2003). The facility removes volatile organic compounds from the ground water through air stripping and hexavalent chromium through ion-exchange.

Figure 6. Treatment Facility C Southeast (TFC-SE; PTU1) started operation in January 1997 (Hoffman et al., 1998). The facility removes volatile organic compounds from the ground water through air stripping and hexavalent chromium through ion-exchange. In April 2006, an additional well was added to this facility as part of the TFC Hotspot milestone.

Figure 7. Treatment Facility D (TFD) started operation in September 1994 (Hoffman et al., 1995). The facility removes volatile organic compounds from the ground water through air stripping. In September 2005, additional wells were added to the facility as part of the TFD Hotspot milestone.

Figure 8. Treatment Facility D East (TFD-E; PTU8) started operation in September 1997 (Hoffman et al., 1998). The facility removes volatile organic compounds from the ground water through air stripping. Additional wells were added to this facility in August 2006 as part of the TFD East Traffic Circle North milestone.

Figure 9. Vapor Treatment Facility D East Traffic Circle South (VTFD-ETCS; VES11) started operation in July 2005 (Karachewski et al., 2006). The facility removes volatile organic compounds from the soil vapor through granular activated carbon.

Figure 10. Treatment Facility D Helipad (TFD-HPD; PTU10) started operation in September 1999 as a treatability test, and became part of the TFD Helipad milestone in June 2004 (Karachewski et al., 2005). The facility removes volatile organic compounds from the ground water through air stripping.

Figure 11. Vapor Treatment Facility D Helipad (VTFD-HPD; VES07) started operation in June 2004 (Karachewski et al., 2005). The facility removes volatile organic compounds from the soil vapor using granular activated carbon.

Figure 12. Vapor Treatment Facility D Hotspot (VTFD-HS; VES13) started operation in September 2005 (Karachewski et al., 2006). The facility removes volatile organic compounds from the soil vapor through granular activated carbon.

Figure 13. Treatment Facility D South (TFD-S; PTU2) started operation in June 1999 (Aarons et al., 2000). The facility removes volatile organic compounds from the ground water through air stripping.

Figure 14. Treatment Facility D Southeast (TFD-SE; PTU11) started operation in March 1998 (Aarons et al., 1999). The facility removes volatile organic compounds from the ground water through air stripping. Additional wells were added to this facility in July 2005 as part of the TFD East Traffic Circle South milestone.

Figure 15. Treatment Facility D Southshore (TFD-SS; PTU12) started operation in June 2000 with a different unit than pictured above (Aarons et al., 2001). The facility removes volatile organic compounds from the ground water through air stripping.

Figure 16. Treatment Facility D West (TFD-W; PTU6) started operation in April 1997 (Hoffman et al., 1998). The facility removes volatile organic compounds from the ground water through air stripping. In May 2003, an additional well was added to this facility as part of the TFC Northeast milestone.

Figure 17. Treatment Facility E East (TFE-E; PTU3) started operation in November 1996 (Hoffman et al., 1997). The facility removes volatile organic compounds from the ground water through air stripping.

Figure 18. Vapor Treatment Facility E Eastern Landing Mat (VTFE-ELM; VES05) started operation in September 2003 (Karachewski et al., 2004). The facility removes volatile organic compounds from the soil vapor through granular activated carbon.

Figure 19. Treatment Facility E Hotspot (TFE-HS; GTU07) started operation in August 2005 (Karachewski et al., 2006). The facility removes volatile organic compounds from the ground water through granular activated carbon.

Figure 20. Vapor Treatment Facility E Hotspot (VTFE-HS; VES12) started operation in August 2005 (Karachewski et al., 2006). The facility removes volatile organic compounds from the soil vapor through granular activated carbon.

Figure 21. Treatment Facility E Northwest (TFE-NW; PTU9) started operation in June 1998 (Aarons et al., 1999). The facility removes volatile organic compounds from the ground water through air stripping.

Figure 22. Treatment Facility E Southeast (TFE-SE; MTU04) started operation in March 2001 (Dibley et al., 2002). The facility removes volatile organic compounds from the ground water through air stripping.

Figure 23. Treatment Facility E Southwest (TFE-SW; MTU03) started operation in June 2000 (Aarons et al., 2001). The facility removes volatile organic compounds from the ground water through air stripping.

Figure 24. Treatment Facility E West (TFE-W; MTU05) started operation in April 2001 (Dibley et al., 2002). The facility removes volatile organic compounds from the ground water through air stripping.

Figure 25. Treatment Facility G-1 (TFG-1; GTU01) started operation in April 1996 (Hoffman et al., 1997). The facility removes volatile organic compounds from the ground water through granular activated carbon.

Figure 26. Treatment Facility G North (TFG-N; MTU02) started operation in July 2003 (Karachewski et al., 2004). The facility removes volatile organic compounds from the ground water through air stripping.

Figure 27. Treatment Facility 406 (TF406; PTU5) started operation in August 1996 (Hoffman et al., 1997). The facility removes volatile organic compounds from the ground water through air stripping.

Figure 28. Vapor Treatment Facility 406 Hotspot (VTF406-HS; VES08) started operation in August 2005 (Karachewski et al., 2006). The facility removes volatile organic compounds from the soil vapor through granular activated carbon.

Figure 29. Treatment Facility 406 Northwest (TF406-NW; GTU03) started operation in July 2002 (Dibley et al., 2003). The facility removes volatile organic compounds from the ground water through granular activated carbon.

Figure 30. Treatment Facility 518 North (TF518-N; STU09) started operation in January 2000 (Aarons et al., 2001). The facility removes volatile organic compounds from the ground water through granular activated carbon.

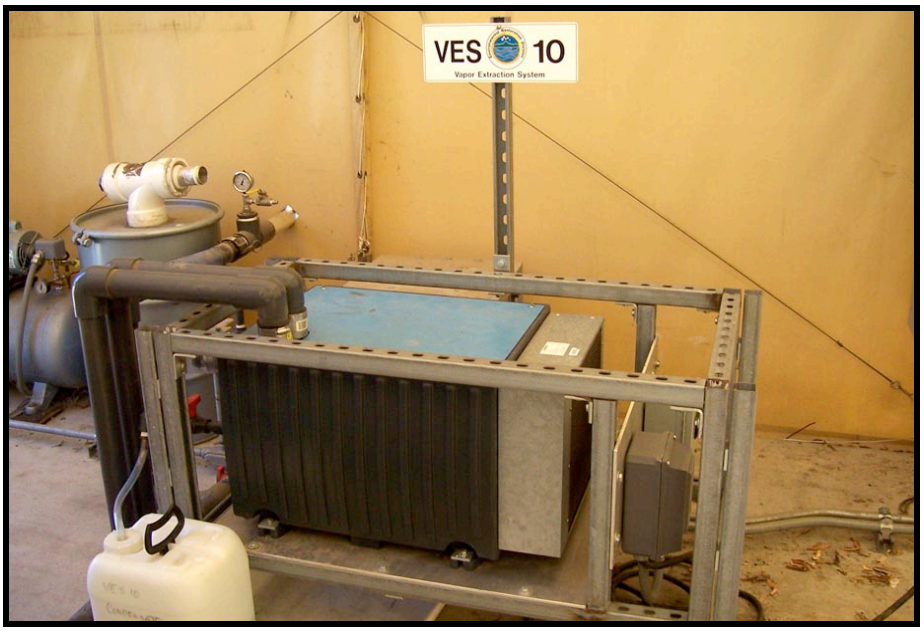

Figure 31. Vapor Treatment Facility 518 Perched Zone (VTF518-PZ; VES10) started operation in September 2004 (Karachewski et al., 2005). The facility removes volatile organic compounds from the soil vapor through granular activated carbon. A different unit operated previously in this location to remove a source of volatile organic compounds from soil vapor at deeper depths.

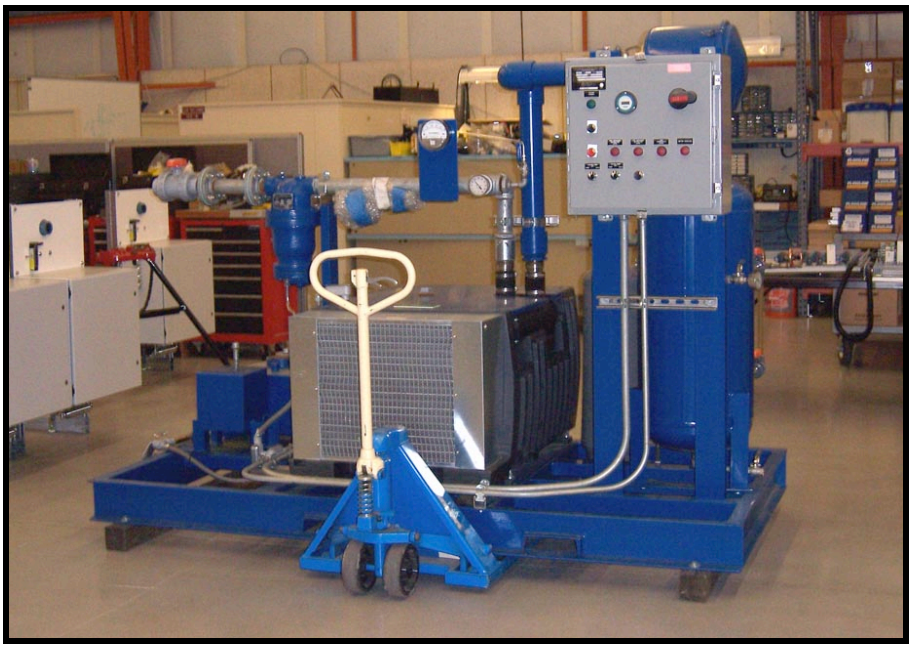

Figure 32. Vapor Treatment Facility 511 (VTF511; VES14) will start operation in September 2006 (Dresen et al., 1993). The facility will remove volatile organic compounds from the soil vapor at Buildings 511 and 419 through granular activated carbon.

Figure 33. Treatment Facility 5475-1 (TF5475-1; CRD1) started operation in September 1998 (Aarons et al., 1999). The facility removes volatile organic compounds from ground water through catalytic reductive dehalogenation and reinjects the water containing tritium back into the subsurface to decay naturally per the Record of Decision (DOE, 1992).

Figure 34. Treatment Facility 5475-2 (TF5475-2; GTU09) started operation in March 1999 with a different unit than pictured above (Aarons et al., 2000). The facility removes volatile organic compounds from the ground water through granular activated carbon. The unit shown above started operation in June 2006.

Figure 35. Treatment Facility 5475-3 (TF5475-3; CRD2) started operation in September 2000 (Aarons et al., 2001). The facility removes volatile organic compounds from ground water through catalytic reductive dehalogenation and reinjects the water containing tritium back into the subsurface to decay naturally per the Record of Decision (DOE, 1992). In September 2001 additional ground water wells and the capability to reinject warm air from the VTF5475 facility was added to the facility as part of the TF5475 CRD Phase 3 milestone. An additional well was added to the facility in June 2006 as part of the TF5475 South milestone.

Figure 36. Vapor Treatment Facility 5475 (VTF5475; VES01) started operation in January 1999 (Aarons et al., 2000). The facility removes volatile organic compounds from the soil vapor through granular activated carbon and reinjects the vapor containing tritium back into the subsurface to decay naturally per the Record of Decision (DOE, 1992).

Attachment 2

Methodology to Estimate Dissolved Subsurface VOC Mass

Methodology to Estimate Dissolved Subsurface VOC Mass

The following outlines the methods utilized to obtain dissolved VOC mass above the Maximum Contaminant Level (MCL) and volume in the saturated zone for the Livermore Site. The basis of this procedure involves:

- Developing a structure model that consists of the hydrostratigraphic units (HSUs).
- Defining the saturated portion of the HSUs using the water table.
- Developing representative VOC distribution maps for each HSU and discretizing the domain into individual grid cells.
- Integrating VOC concentrations vertically over the saturated portion of the HSU.
- Summing the volume of water with VOC concentrations above the MCL and calculating VOC mass for each grid cell to obtain total volume and mass.

A three-dimensional layered geologic model of the subsurface at Livermore Site was developed using the EarthVision (Dynamic Graphics Inc., 2002) geologic modeling software to define the HSU layers that are generally separated by laterally continuous low permeability paleosols (Noyes et al., 2000). The upper and lower boundaries of the HSUs were based on geologic interpretation of lithological logs, geophysical logs, hydraulic and chemistry data from 913 boreholes/wells.

To obtain the saturated portions of the HSUs, the top of each HSU is truncated by the water table using a representative static potentiometric surface; this typifies minimal perturbations (pumping and recharge) to the system. The volume bounded by the bottom of the HSU, top of the HSU and/or the ground water surface represents the saturated thickness of the HSU. To calculate the volume of water in the pore space, the saturated thickness is multiplied by a HSU specific porosity value.

The distribution of VOCs within the HSU was derived from the Plume History Analysis (PLUHA) maps. PLUHA maps detail the history of each of our 13 VOCs by combining all available soil and ground water chemical data, subsurface structure and remediation history using a defensible set of decisions that are consistent and representative for each time period. The entire procedure dating back to 1987 gets updated each quarter to include updated chemistry, structure and remediation data. Currently, PLUHA uses data collected from 633 wells and boreholes. Data from PLUHA is regionalized on a 203 x 125 grid with cell dimensions of 64 ft x 64 ft.

Once the contaminant distribution is known, it is assumed that it is integrated and well-mixed vertically within the HSU. The VOC concentration in each 64 ft x 64 ft cell is multiplied by the saturated volume that contains VOC concentrations above the MCL

values for each VOC to obtain mass. The total mass within the HSU is a summation of all masses computed for each cell.

This procedure only calculates mass dissolved in the saturated portion of each HSU. It does not compute mass in the vadose zone or mass in the sorbed phase. This assumption is particularly important in the source areas because significant amounts of VOC mass remain in the vadose zone and in the sorbed phase in the saturated zone which would increase the estimated mass.

References

Dynamic Graphics Inc. (2002), EarthVision User's Guide. Dynamic Graphics Inc., Alameda, CA.

Noyes, C.M., M.P. Maley and R.G. Blake (2000), *Defining Hydrostratigraphic Units within the Heterogeneous Alluvial Sediments at Lawrence Livermore National Laboratory*, Lawrence Livermore National Laboratory, Livermore, CA (UCRL-JC-139779).

Attachment 3

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